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Fig. 1.

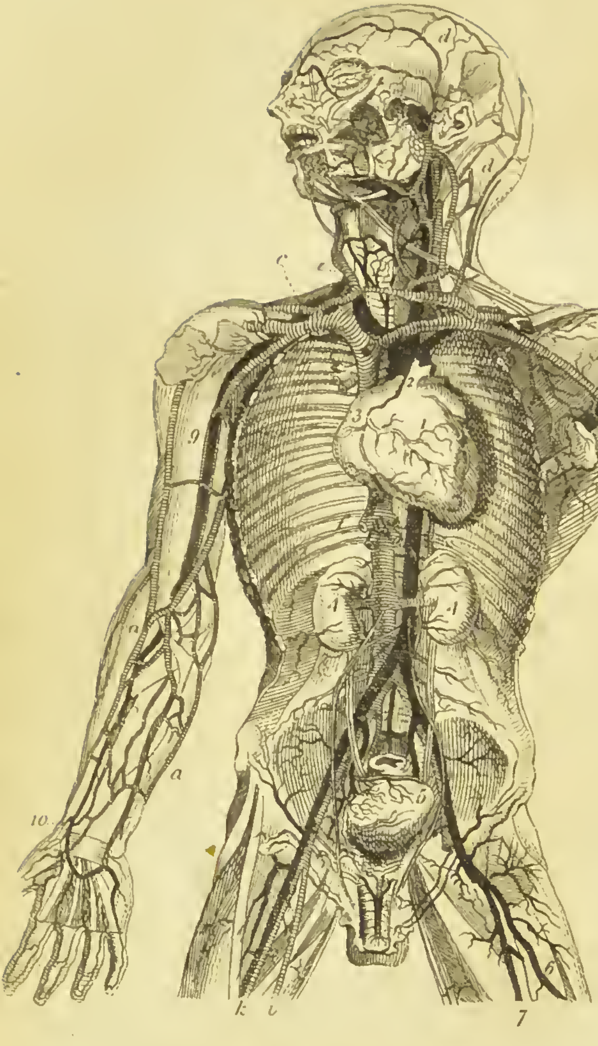

Fig. 2.

THE POPULAR COMPENDIUM OF ANATOMY:

OR, A CONCISE AND CLEAR

DESCRIPTION

OF

THE HUMAN BODY;

WITH THE

PHYSIOLOGY, OR NATURAL HISTORY

OF THE VARIOUS ACTIONS AND FUNCTIONS OF ITS DIFFERENT ORGANS AND PARTS.

Containing also an Article

ON SUSPENDED ANIMATION,

With the proper Means to be used for the Recovery of drowned Persons.

BY WILLIAM BURKE, SURGEON.

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PREFACE.

TO know the genius and powers of an artist, it is necessary to study his works: here can we best form a true opinion of the greatness of his designs, and the ability of his execution. So is it with respect to the Creator and his wonderful works; in contemplating the great volume of the universe alone, do we read the attributes of the Supreme Being. Who, for a moment, can behold the immensity of creation, without owning the omnipotent powers of its author? We see his wisdom in the mechanism and order which pervade the whole; while the abundance with which he strews the earth, for supplying the wants and comforts of his children, proves his great munificence and love for man.

These considerations necessarily lead man to a pure devotion; he feels his dependence, as he measures the power of his God; his reverential awe is proportionate

to the wisdom he discovers in the laws of creation; and his gratitude flows in a like abundance for the gifts of the Creator. This is the natural consequence of studying the Supreme Being in his works: we are convinced by facts; and those facts are immutable and universal.

Could all the children of the human race but understand the nature of the creation they inhabit, no doubt, they would soon cease to oppose obstacles to the completion of its great and sublime results; all would eagerly press forward to assist the Creator in accomplishing the harmony and happiness of the wonderful whole. This is the universal interest of man, and sooner or later must take place.

With this view a knowledge of nature is of the utmost benefit; it is the science of the attributes of the Supreme Being, and what enables us to read his will in the disposition of his works.

Man, perhaps, of all the objects in nature, presents the most comprehensive view of the sublime attributes of the Deity;

his structure is an epitome of the power, the wisdom, and the beneficence of the Creator. We see a divine contrivance in every part of his organization; and whether we examine the astonishing operations of the human mind, or confine our researches to the material frame of man, we trace the divine architect in all, and are necessarily led to admire and love the author and his works.

"Astronomy and anatomy," says Fontenelle, "are the studies which present us with the most striking view of the two greatest attributes of the Supreme Being: the first of these fills the mind with the idea of his immensity, in the largeness, distances, and number of the heavenly bodies; the last, astonishes with his intelligence and art in the variety and delicacy of animal mechanism."

The human body has been called by the ancients by the name of microcosmus, or the little world; as if it did not differ so much from the universal system of nature, in the symmetry and number of its parts,

as in their size: and with this impression, Cicero, and other philosophers, dwell more on the structure and œconomy of the body of man, than on all the productions of nature besides, when they want to prove the existence of the Gods, from the order and beauty of the universe.

Certainly the structure and functions of man, when studied with a view towards the Creator, fill the soul with the most sublime and awful sensations. Who can know and consider the evident proofs of the goodness and astonishing powers of the Creator, informing and sustaining a beautiful animal body capable of the highest enjoyments, and surrounded with the objects of its happiness, as we are, without feeling the most exalted enthusiasm? Can the mind seriously reflect upon this grand and sublime subject, without being filled with adoration; without longing for another life after this, in which we may be gratified with the most exquisite enjoyment which our faculties and nature seem capable of, the seeing and comprehending the whole

plan of the Creator in forming the universe, and in directing all its operations.

But this study, edifying and delightful as it is, is almost shut out from the bulk of mankind. Its technical terms are remote, often unmeaning, and frequently mislead the mind, by presenting images different from the true figure of the parts, which those terms would designate: besides that it requires years spent in acquiring a knowledge of the Greek and Latin languages, to be able to comprehend the meaning of those terms.

Another obstacle to the extension of this study arises from the plan and expence of the books hitherto written on human anatomy. They have been adapted to the purposes of the professional student, and not to gratify the laudable curiosity of the general reader. They have presupposed a familiarity with dissections, the only just foundation, indeed, of accurate anatomical knowledge, but which are not sufficiently inviting, or indeed accessible, to the class of readers whose instruction and enter-

tainment are aimed at in this little publication. The more compendious books on anatomy consist of mere descriptions of the organs, and have but scanty references to the purposes for which they were designed; while the larger anatomical works, which have included the philosophy of the functions together with the anatomy of man, are too voluminous and too expensive for popular use. The author hopes, that while he has avoided in this publication a tedious minuteness of description, in the part which is merely anatomical, (and which would have fatigued the attention without informing the understanding of the reader, unless the work had been illustrated by more plates than was compatible with cheapness of form,) he conveys such an idea of the structure of the human body as will explain the uses to which the parts are applied, and point out that astonishing adaptation of means to ends, which renders human anatomy of all pursuits, perhaps, the most interesting. The compiler of these sheets

cannot flatter himself that he has surmounted all the difficulties which lay before him, but he has aimed at perspicuity, simplicity, and conciseness; and while he professes to lay himself out for the guidance of the unprofessional reader in a track of knowledge to which the access is encumbered by many difficulties, and not a few discouragements; he is tempted to hope that his little volume may be placed with advantage in the hands of the young anatomical student, as a prelude to his severer reading; and that to both classes he has given such a sketch of the organization and functions of man, as will extend their views of creation, instigate them to keener inquiries into natural knowledge, and animate them with feelings of a more elevated devotion towards the great Creator of all things.

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A

COMPENDIUM

OF

ANATOMY.

INTRODUCTORY VIEW OF THE HUMAN BODY.

IN order, said the late Dr. Hunter, in his introductory Lecture to Anatomy, to be able to know for what purpose the human body is made to consist of such a variety of parts; why it possesses such a complication of nice and tender machinery; and why there was not rather a more simple, less delicate, and less expensive frame, it is necessary that we, in our imagination, make a man: in other words, let us suppose that the mind or immaterial part is to be placed in a corporeal fabric, in order to hold a correspondence with other material beings by the intervention of the body; and then consider *à priori*, what will be wanted for her accommoda-

tion. In this enquiry we shall plainly see the necessity and advantage, and therefore the final cause, of most of the parts which we actually find in the human body. And if we consider that in order to answer some of the requisites, human wit and invention would be very insufficient; we need not be surprised if we meet with some parts of the body whose use we cannot yet perceive, and with some operations and functions which we cannot explain. We can see that the whole bears the most striking characters of excelling wisdom and ingenuity: but the imperfect senses and capacity of man cannot pretend to reach every part of a machine, which nothing less than the intelligence and power of the Supreme Being could contrive and execute.

First, then, the mind, the thinking, immaterial agent, must be provided with a place of immediate residence, which shall have all the requisites for the union of spirit and body; accordingly she is provided with the brain, where she dwells as governor and superintendant of the whole fabric.

In the next place, as she is to hold a correspondence with all the material beings around her, she must be supplied with organs fitted to receive the different kinds of impression which they will make. In fact, therefore, we see that she is provided with the organs of sense, as we call them;

the eye is adapted to light; the ear to sound; the nose to smell; the mouth to taste; and the skin to touch.

Further, she must be furnished with organs of communication between herself in the brain, and those organs of sense, to give her information of all the impressions that are made upon them; and she must have organs between herself in the brain, and every other part of the body, fitted to convey her commands and influence over the whole. For these purposes the nerves are actually given. They are soft white chords which rise from the brain, the immediate residence of the mind, and disperse themselves in branches through all parts of the body. They convey all the different kinds of sensations to the mind in the brain; and likewise carry out from thence all her commands to the other parts of the body. They are intended to be occasional monitors against all such impressions as might endanger the well-being of the whole, or of any particular part; which vindicates the creator of all things, in having actually subjected us to those many disagreeable and painful sensations which we are exposed to from a thousand accidents in life.

Moreover, the mind, in this corporeal system, must be endued with the power of moving from place to place; that she may have intercourse with a variety of objects; that she may fly from such

as are disagreeable, dangerous, or hurtful; and pursue such as are pleasant and useful to her. And accordingly she is furnished with limbs, with muscles and tendons, the instruments of motion, which are found in every part of the fabric where motion is necessary.

But to support, to give firmness and shape to the fabric; to keep the softer parts in their proper places; to give fixed points for, and the proper directions to its motions, as well as to protect some of the more important and tender organs from external injuries, there must be some firm prop-work interwoven through the whole. And in fact, for such purposes the bones are given.

The prop-work is not made with one rigid fabric, for that would prevent motion. Therefore there are a number of bones.

These pieces must all be firmly bound together, to prevent their dislocation. And this end is perfectly well answered by the ligaments.

The extremities of these bony pieces, where they move and rub upon one another, must have smooth and slippery surfaces for easy motion. This is most happily provided for, by the cartilages and mucus of the joints.

The interstices of all these parts must be filled up with some soft and ductile matter, which shall keep them in their places, unite them, and at the

same time allow them to move a little upon one another; these purposes are answered by the cellular membrane or adipose substance.

There must be an outward covering over the whole apparatus, both to give it compactness, and to defend it from a thousand injuries; which, in fact, are the very purposes of the skin and other integuments.

Lastly, the mind being formed for society and intercourse with beings of her own kind, she must be endued with powers of expressing and communicating her thoughts by some sensible marks or signs, which shall be both easy to herself, and admit of great variety: and accordingly she is provided with the organs and faculty of speech, by which she can throw out signs with amazing facility, and vary them without end.

Thus we have built up an animal body which would seem to be pretty complete; but as it is the nature of matter to be altered and worked upon by matter, so in a very little time such a living creature must be destroyed, if there is no provision for repairing the injuries which she must commit upon herself, and those which she must be exposed to from without. Therefore a treasure of blood is actually provided in the heart and vascular system, full of nutritious and healing particles, fluid enough to penetrate into the minutest parts of the

animal; impelled by the heart, and conveyed by the arteries, it washes every part, builds up what was broken down, and sweeps away the old and useless materials. Hence we see the necessity or advantage of the heart and arterial system.

What more there was of the blood than enough to repair the present damages of the machine, must not be lost, but should be returned again to the heart; and for this purpose the venous system is provided. These requisites in the animal explain the circulation of the blood, *à priori*.

The old materials which were become useless, and are swept off by the current of blood, must be separated and thrown out of the system. Therefore glands, the organs of secretion, are given for straining whatever is redundant, vapid, or noxious, from the mass of blood; and when strained, they are thrown out by emunctories, called organs of excretion.

But as the machine is constantly in action, the reparation must be carried on without intermission, and the strainers must always be employed. Therefore there is actually a perpetual circulation of the blood, and the secretions are always going on.

Even all this provision, however, would not be sufficient; for that store of blood would soon be consumed, and the fabric would break down if there was not a provision made for fresh supplies.

These, we observe, in fact, are profusely scattered round her in the animal and vegetable kingdoms; and she is furnished with hands, the fittest instruments that could be contrived for gathering them, and for preparing them in a variety of ways for the mouth.

But these supplies, which we call food, must be considerably changed; they must be converted into blood. Therefore she is provided with teeth for cutting and bruising the food, and with a stomach for melting it down: in short, with all the organs subservient to digestion. The finer parts of the aliments only can be useful in the constitution; these must be taken up and conveyed into the blood, and the dregs must be thrown off. With this view the intestinal canal is provided. It separates the nutritious part, which we call chyle, to be conveyed into the blood by the system of absorbent vessels; and the coarser parts pass downwards to be ejected.

We have now got our animal not only furnished with what is wanting for its immediate existence, but also with powers of protracting that existence to an indefinite length of time. But its duration, we may presume, must necessarily be limited; for as it is nourished, grows, and is raised up to its full strength and utmost perfection; so it must in time, in common with all material beings, begin

to decay, and then hurry on to final ruin. Hence we see the necessity of a scheme for its renovation. Accordingly wise Providence, to perpetuate, as well as to preserve his work, besides giving a strong appetite for life and self-preservation, has made animals male and female, to continue the propagation of the species to the end of time.

Thus we see, that by the very imperfect survey which human reason is able to take of this subject, the animal man must necessarily be complex in his corporeal system, and in its operations.

He must have one great and general system, the vascular, branching through the whole for circulation: another, the nervous, with its appendages the organs of sense, for every kind of feeling: and a third, for the union and connection of all these parts.

Besides these primary and general systems, he requires others which may be more local or confined: one for strength, support, and protection, the bony compages: another for the requisite motions of the parts among themselves, as well as for moving from place to place, the muscular system: another to prepare nourishment for the daily recruit of the body, the digestive organs: and one for the continuance of the species.

In taking this general survey of what would appear originally to be necessary for adapting an ani-

mal to the situations of life, we observe, with great satisfaction, that man is accordingly made of such systems, and for such purposes. He has them all; and he has nothing more, except the organs of respiration. Breathing it seemed difficult to account for *à priori*; we only know it from observation to be essential to life. Notwithstanding this, when we see all the other parts of the body, and their functions, so well accommodated for, and so wisely adapted to their several purposes, there can be no doubt that respiration is so likewise: accordingly the discoveries of Dr. Priestley, and of later enquirers, have thrown light upon this function also, as will be shewn in its proper place.

Of all the different systems in the human body, the use and necessity are not more apparent than the wisdom and contrivance which has been exerted in putting them all into the most compact and convenient form; in disposing them so, that they shall mutually receive, and give helps to one another; and that all or many of the parts shall not only answer their principal end or purpose, but operate successfully and usefully in a variety of secondary ways.

If we consider the whole animal structure in this light, and compare it with any machine in which human art has exerted its utmost skill; suppose the best contrived ship that ever was built; we shall be

convinced beyond the possibility of doubt, that intelligence and power has been exerted in its formation far surpassing what humanity can boast of.

One superiority in the animal economy is peculiarly striking. In machines of human contrivance there is no internal power, no principle in the machine itself, by which it can alter and accommodate itself to any injury which it may suffer, or remedy any mischief which admits of repair. But in the animal body this is most wonderfully provided for by the internal powers of the system; many of which are not more certain and obvious in their effects than they are above all human comprehension as to the manner and means of their operation. Thus a wound heals by a natural process; a broken bone is made firm again by a deposit of new bony matter; a dead part is separated and thrown off; noxious juices are driven out by some of the emunctories; a redundancy is removed by some spontaneous bleeding; a bleeding naturally stops of itself; a great loss of blood from any cause, is in some measure compensated by a contracting power in the vascular system, which accommodates the capacity of the vessels, to the quantity contained. The stomach gives information when the supplies have been exhausted; represents with great exactness the quantity and quality of what is wanted in the present state of the machine; and

in proportion as she meets with neglect rises in her demand, urges her petition in a louder tone, and with more forcible arguments. For the protection of the animal amidst the fluctuations in the heat of external bodies, a power of generating it has been provided; and to prevent its undue accumulation in a heated atmosphere, or its excessive abstraction in a cold one, the quantity carried away is regulated with wonderful nicety to its wants; so that an equal temperature is preserved in all the range of climates, from the extreme point of habitable existence near the poles, to the intense heat of the equatorial regions.

A farther excellence or superiority in the natural machine, if possible still more astonishing, more beyond all human comprehension, than what we have been speaking of, is, besides those internal powers of self-preservation in each individual, the capability those individuals possess of creating together beings like themselves, which are again endued with similar powers for producing others, and so of multiplying the species without end.

These are powers which mock all human invention or imitation. They are characteristics of the divine architect.

OF THE BONES.

The bones, constituting, as was before observed, the basis and support of the body, are necessarily its most hard and solid parts; appearing to superficial observation to be merely inorganic concretes; resisting for ages the test of time; and remaining awful memorials of the decay of past generations. Hence, some have been led to think they were without organization, and consequently not liable, like the soft parts of the body, to disease and death. But this erroneous opinion is refuted by minute dissection, which discovers the internal structure of bones, traces their numerous vessels, and shews them to be supplied with blood like the softer parts; and also, that, like these parts, they have their periods of growth and decay, and are liable equally with them to internal diseases, and to derangement from external injuries.

If, for instance, the vessels of an adult bone be injected with red coloured wax, and the earthy particles be dissolved by a mineral acid; the bone will be reduced to a membranous state; but a gelly full of vessels will remain; and these vessels will now appear as numerous as in the fleshy parts; a proof that they were before concealed only by the earthy portion of the bone.

Before birth all the bones of the fœtus are but cartilage. This cartilage is not, as was erroneously supposed, hardened into bone; but is absorbed and carried away by one set of vessels, while another set is employed in depositing, in its room, matter for forming the new bones. This process is effected in the following manner.

The transparent vessels of the cartilage first begin to dilate to receive the red blood; at this time an artery can be observed penetrating towards the middle of the bone; this artery is soon accompanied by others, all forming a sort of network, and conveying red blood; and now ossification may be said to have commenced. Gradually the cartilage grows opake and brittle, and will no longer bend. The ossific centre spreads according to the dimensions of the bone; it may be known by its hard feel, when examined by a sharp instrument: similar points of ossification now take place, and in a like manner, in other parts of the bone, till its whole body becomes opake; and now the vessels stretching from the centre towards the extremities, having penetrated the cartilages which separate the heads from the body of the bone, enter these heads, when ossification commences here also. From this mode of process it will be seen, that the heads and body are at first distinct bones, formed separately and connected

only by cartilage, and they are not united till the age of eighteen or twenty years.

Thus the formation of bone is effected by the action of its blood vessels, which may be seen entering in one great trunk into the body of each bone, and spreading thence towards both extremities. It is by this action all the parts of the body are evolved; it forms the blood, as is seen in the case of the chick, which has no other way of receiving this fluid, but by forming it within its own body; and from the blood, are all the solids constructed by the same action of the vessels. All animals have the power of assimilating their food, and with the assistance of air, of converting it into blood; and as by the action of their larger vessels they can thus elaborate fresh supplies of red blood, so the action of particular vessels is intended to prepare particular parts. Thus some add to the solids to assist growth; others for supplying the continual waste; while more are employed in effecting the different secretions within the body, and one of which is the formation of bone. In this manner then is ossification accomplished; the arteries of the transparent cartilage of the fœtus, beginning at length to receive the red blood, commence their deposition of earthy matter; this at first appears in numerous specks, which spreading, afterwards meet, and at last constitute perfect

bone. But, while these arteries are thus employed in depositing bone, there are other vessels, (called absorbents, from the nature of their function) busily engaged in removing away the cartilage, modelling the new bone into its proper form, shaping out its cavities, and also hardening it into due consistence.

This organization of arteries to deposite bone, and of absorbents to convey away the cartilage, which was necessary to its formation and growth, is also essential to the life and health of the full formed bone. And, indeed, the latter depends on the regular deposition and reabsorption of the parts: for by varying the degree of action in either of these operations, bone may be made to inflame and ulcerate like the softer parts, or to become too brittle by an over secretion of earth, or too soft from its excessive absorption. It is this earth which constitutes the hardness, and, indeed, all the serviceable properties of bone: it lies dead and in the inorganic interstices of the membrane, and is united with animal mucilage to give it consistence and strength.

That the bones, in common with the rest of our frames, suffer a constant renovation of parts, is proved by the following experiment. If madder be given to animals, then withheld for some time, and afterward given again: in twenty-four hours

after it had been first given, all their bones will become tinged; and in two or three days the colour becomes very deep; in a few days after the madder has been discontinued, the red colour disappears; but on its being again given to the animals, their bones become a second time tinged. Further, the absorption of bones, is also proved by the disappearance of a carious or dead bone, even before the skin is opened; and by the destruction of a bone, merely from the pressure of a tumor against it: in which cases the bone must have been taken up by the absorbing vessels and conveyed away: and lastly, this absorption is placed beyond all controversy by the fatal disease called "mollities ossium;" which in a short time dissolves and carries off, by an excessive action of the absorbents, the bony system; discharging the earthy matter by the kidneys, and gradually rendering the bones soft, till they bend under the weight of the body and may be cut with a knife.

But this vascular conformation of bones not only sustains their health by constantly removing and carrying off their wasted and unsound particles, and furnishing them with new ones; but also, by extending to them the circulation in common with the other parts of the body, it enables those useful organs to repair their injuries by uniting such as may be broken. And here we cannot help ad-

miring the beneficence as well as wisdom of the Creator, who thus kindly interweaves, not only with the soft parts of the human machine, but also with its most hard and solid substances, the means of supplying their waste and likewise of repairing their injuries.

If, for instance, a bone be fractured, its broken ends will unite in the following manner: first, the arteries discharge a thin mucus, which afterwards thickens into a transparent gelly and becomes vascular, by the elongation of vessels from the neighbouring parts; these vessels soon begin to secrete the osseous matter, till the whole gelly becomes one bony mass, and thus the fractured ends are completely united. And that this desirable result may be the more certain, the formation of new bony matter is not confined to any one part or to particular vessels in the bone; but is generously bestowed upon its entire system: for not only will the vessels of the periosteum or membrane covering and lining bones produce fresh osseous matter; but so also will those of the bone itself; as will likewise the vessels of the marrow, which is contained within the cavity of the bones. Thus, if by puncturing the bone of an animal we destroy the marrow, the old bone decays, and a new one will be formed from the periosteum: and, should the creature soon afterwards die, and

the bone be inspected, it will be found to be a secretion from the inner surface of the periosteum, bearing all the characteristics of true bone, and containing within it the old bone, dead and black. If, on the other hand, this experiment be reversed, and the periosteum only is destroyed, preserving the nutritious vessels of the bone; in this case the new bony matter is elaborated by the medullary vessels, and the old bone surrounding it, will become black and dead. Lastly, when the knee-pan, where there is no medullary vessels, is fractured, the broken parts are united by the intervention of a callus, secreted from the vessels of the bone itself.

Again, if a bone is injured by blows or other accidents, which derange its economy and damage its structure, the circulation soon repairs the mischief in the following manner. First, inflammation takes place, as in the soft parts of the body; next, a swelling and spongy looseness with a fulness of blood ensue; suppuration and ulceration soon follow; and finally, the diseased bone becomes completely dead, and is discharged from the system.

Bones, besides arteries, veins, and absorbing vessels, have also, like the soft parts, their nerves: these may be discovered entering like small threads into the body of the bone, in company

with its nutritious vessels; and yet, notwithstanding we can trace the course of some of these nerves, a bone appears to possess no sensibility. Thus, rasping the periosteum, and even scraping it from the bone, produces no pain; in amputation bones are cut without exciting particular feeling; and even the application of the actual cautery formerly in use, was known to produce only a kind of heat along the course of the bone, not unpleasant to the patient. But it must not be supposed from these facts that bones are wholly insensible, they are in reality otherwise; but their sensibility being fitted to their functions, is so regulated as not to appear under the generality of those circumstances, which produce it in the soft parts of the body. Hence the shocks from running, leaping, and other violent exercises, cause no sensation in the bones; and which, if otherwise ordered, must have subjected them to almost continued pain, from the numerous blows and other accidents they are obliged to suffer. The same wise economy is extended to the cartilages, ligaments, and other parts composing the joints, and for the same reason; namely, to prevent the occurrence of pain on every uneasy motion or concussion which these parts are liable to endure.

But though bones exhibit this inaptitude to sensibility, in their healthy state, and on ordinary

occasions; this is far from being the case when they are diseased. Injuries will produce inflammation in the bones as well as in the soft parts, and now their hidden sensibility becomes roused, and even surpasses that of the latter, though excited from a like condition. This is also the case with the cartilages, ligaments, and all the other parts in which sensibility appears dull during health. Thus the wound of a joint is certainly less painful at first, but inflammation comingon, the sensibility of the injured parts rises to an alarming height, so as to compel the wretched sufferer to roar from torture; and now no pains are felt to equal those arising from bones and joints.

From this view of the subject it will be seen that ossification is a process of a truly animal nature; and that bone is a regularly organized substance, whose form subsists from the first. Bone partakes by its vessels of the general changes with all the other parts of the body; the absorbents removing the old wasted parts, while the arteries are constantly depositing new ones; and thus it lives, grows, and is enabled to repair its injuries. Ossification is at first rapid; advances slowly after birth; but is not completed in the human body till the twentieth year; it is forwarded by health and strength of constitution; and is retarded by weakness and disease. In scrophula it is imperfect;

and so children become rickety, the bones softening and swelling at their heads, and bending under the weight of the body.

The structure of bones, as may be seen by breaking those old and decayed ones which are found in church-yards, consists of plates made up of fibres, and those plates connected together by other fibres; by which formation a great number of interstices or cells are to be met with in the heads of the long bones, while their sides have a denser, and more firm construction.

The Periosteum.

The bones are covered with a membrane, called on that account periosteum; it adheres closely to their surface, by small points, which dive into the outward substance of the bones, so that it may bear the pulling of the great tendons, which are fixed rather into the periosteum than into the bone; it is also connected with the bones by innumerable vessels, which are transmitted to them through the medium of this membrane. The periosteum is not itself vascular, and appears to be merely condensed cellular membrane; if, however, it be hurt by injuries, the outer layers of the bone die; because the vessels which nourished and sustained their health, are now destroyed or prevent-

ed from continuing their function, by the injury of the membrane through which they passed into the bone: but the internal layers will now set about repairing the mischief; these, being fully nourished by the internal arteries, inflame, swell, become porous and spongy, form granulations, and these granulations push off the mortified plate, and form themselves into new bone, which supplies its place.

The uses of the periosteum appear to be, to nourish, by the vessels which pass through it, the external layers of the bone; to afford a convenient origin and insertion to several muscles and tendons which are fixed into this membrane; and to prevent, by the looseness of the external surface, friction, in the sliding of the muscles over the bones.

The Marrow.

The marrow is an oily secretion from the blood, and is lodged in membranous vesicles which fill up the larger and smaller cavities within the bones: these minute bags are formed from the membrane which lines the cells within the bones.

The precise use of the marrow is not yet ascertained; but its consistence varies in different periods of life. In infancy it is thin and tinged with blood; it thickens as we advance in life.

The destruction of the marrow, as we before observed, produces the death of the bone in which it is contained; and from the same cause, that injuries of the periosteum will be the means of destroying the external plates, namely, the destruction of the vessels; for, as the periosteum is the medium by which the external vessels are conveyed to the bone, so the internal ones are conducted to its substance by the membrane containing the marrow, and lining the inside of the bone; whence, the marrow being destroyed, the channels for conveying nourishment are cut off, and the bone dies.

Ligaments.

The bones are connected to each other by ligaments, which are strong, white, flexible substances, and but little elastic: they are of two kinds, the round or cord-like ligament, which grows from the head of one bone, and is inserted into that of the other, tying the two bones together; and the capsular ligament, which encloses the whole joint as in a purse or bag, and has numerous arteries opening upon its internal surface, for the purpose of keeping it moist, and of diminishing friction.

Cartilages.

But, the more effectually to preclude friction and concussion, all the bones forming moveable

joints, have their ends covered with plates of cartilage, which being of a solid, smooth, elastic nature, renders all the motions of the joints easy and free from shocks in running, jumping, &c. and to increase this effect, there are also moveable cartilages interposed between the ends of the bones, in some of the joints.

The Synovia.

Besides the fluid which the capsula ligament throws out, there are small fringe-like bodies placed within the joints, for securing a constant and copious supply of moisture. They secrete a singularly glairy and slippery liquor called synovia, for lubricating the different surfaces of the joint, and preventing friction in the various motions of the body: after the synovia has performed its office, it is reassumed into its mass of blood by the absorbent vessels, which arise by open extremities from all the cavities of the body.

Of the Skeleton of the Human Body.*

The bones of an animal connected together, after the soft parts have been removed, is called a skeleton: and is said to be a natural one when they are kept together, as in the living state, by their own ligaments; but artificial if they are

* For the figure of the skeleton see Plate 1.

joined with wire, or any other substance, foreign to the animal.

The human skeleton we shall divide, for the purposes of description, into the head, the trunk, the superior and inferior extremities.

Of the Head.

By the head is meant all that spheroidal part which is placed above the first bone of the neck: it therefore comprehends the bones of the skull, and those of the face.

The Skull.

The skull or brain-case consists of eight bones, which form a vaulted cavity for lodging and defending the brain; this great cavity is proportioned to its contents, which is the cause of such variations in its size in different persons; while its roundish figure is chiefly owing to the equal pressure of the contained parts, as they grow and increase, before the skull is entirely ossified; and to the management of the head during this period is to be attributed the difference of shape observable in different nations: hence, from the use of the turban, the head of a Turk assumes a round figure, greatly different from that oblong shape, which characterizes those nations, with whom the turban is not in use.

A more striking instance of the degree in which the human head may be modelled by national customs, is found among the Caribbee Indians, who by flattening the forehead in early infancy, produce a hideous deformity of aspect.

Some of the Faquirs of India are well known for the cone-like shape to which they mould their heads.

The bones of the skull are composed of two tables, and an intermediate lattice-work, nearly of the same structure and use, as that of the other bones: the outer table or plate is the thicker and stronger of the two, being more immediately concerned in warding off injuries of the head.

The eight bones of the skull are the frontal-bone, which forms the whole fore-part of the skull; the two parietal-bones forming its upper and middle part: the two temporal-bones composing the lower part of the sides: the occipital-bone making the whole hinder part, and some of the base: the ethmoid-bone, placed in the fore-part of the base of the skull: and the sphenoid-bone in its middle.

Sutures.

These bones are joined to each other by what anatomists call sutures, which are indented or dove-tailed seams; their uses are not well understood:

some have supposed that they were intended to limit the extent of fractures in the skull: others, that they enable the dura mater, or membrane lining the inside of the head, to suspend itself more firmly, by insinuating its fibres through those sutures, and communicating with the membrane on the outside; but these opinions, with many others, are contested and admit of doubt; and, perhaps, it is more reasonable to believe that sutures are merely a consequence of the mode in which the ossification of the skull takes place, rather than a formation, designed for certain uses. We see the bones of the skull ossify from the centre towards their circumference, their fibres spreading and extending on every side, till at last those different bones meet, and shooting in between each other, form the suture or serrated line of union. Nature, in the formation of all bones, hastens their ossification, by beginning the process in many points, and she observes this law in healing a broken bone, as well as in forming the skull: had the process of ossification in the head been confined to one point, it must necessarily have been slow and imperfect, and the brain would have continued a long time exposed to injuries from without; but, instead of this, we find a distinct system of ossification going forward at the same time in each of the bones composing the skull, all

spreading from their centres, and approaching each other to make one whole, perfect, bony case for lodging the brain. But it should be observed here, that this ossification is not complete for a long time after birth; the bones not having yet sufficiently grown for their edges to meet. The imperfectly ossified state of the skull appears to be better suited to the growing and increasing condition of the brain during this period, than if its ossification had been quite complete; as in this case the flexibility of the skull must be less, and its capacity not so easily enlarged by the increasing bulk of the brain. One beneficial consequence results from the imperfect ossification of the skull at birth, which is too important to omit, and which, perhaps, was the principal aim nature had in view, in adopting this peculiar structure; namely, the opportunity it affords of contracting the size of the head in parturition. It is almost constantly found that the bones overlap one another very considerably, and lessen the head in both its diameters to a surprising degree.

Bones of the Face.

The face is the irregular pile of bones composing the fore and under part of the head. It constitutes the bony portion of some of the organs of sense, affording sockets or orbits to the eyes, an

arch to the nose, and a support to the palate; it also forms the basis of the human physiognomy, and enters into the composition of the mouth: anatomists, in their description, commonly divide the face into the upper and lower jaws.

The superior jaw is bounded above by the transverse suture, which joins the bones of the face to those of the skull: behind, by the fore part of the sphenoid-bone: and below, by the mouth. It consists of six bones on each side; of a thirteenth placed in the middle, and having no fellow; and of sixteen teeth. The thirteen bones are, viz. the two nasal: two ungular: two cheek-bones: two maxillary bones: two palate bones: two spongy bones of the nose: and the single bone, called the vomer, and which divides the nose.

The two nasal bones form the root and arch of the nose.

The two ungular bones, so called from their resembling the nail of one's finger, constitute the inner angle of each orbit: each of these bones has a deep perpendicular canal for lodging a part of the lachrymal sac and duct, by which the tears are conveyed into the nose; and it is this bone which is operated upon in the disease called fistula lachrymalis, which is an obstruction of the lachrymal duct, by which the tears, instead of flowing off by the nose, trickle over the face. The operation is per-

formed by piercing the bone with an instrument, which opens an artificial communication with the nose, and the tears are conducted through that channel.

The two cheek-bones are the prominent square bones, which form the upper part of the cheeks: they constitute a distinguishing feature in the human countenance, as may be seen by comparing the high cheek-bones of the Tartars, and other northern nations, with the more regularly formed countenances of the people of southern climates.

The two maxillary bones are the largest, and constitute the far greater part of the upper jaw. They form the most part of the nose, a great portion of the roof of the mouth, and also a considerable share of each orbit; at their lower edge they afford a base and sockets for containing the sixteen upper teeth. Each of these bones has a large hollow in its body, which is lined with a continuation of the membrane of the nose; it is called the maxillary sinus, has a small opening into the nostrils, and is supposed to be intended for raising and making the voice more perfect, by creating a reverberation of the sounds: sometimes collections of matter form in this sinus, attended with great pain, inflammation, and swelling of the cheek, and even distortion of the face; in this case the matter is discharged by pulling out the second or third

of the grinding teeth, and introducing a sharp stillet by the socket of the drawn tooth, then perforating the bony partition, which is here generally very thin, into the sinus.

The palate-bones are placed at the back part of the palate or roof of the mouth, and are continued up the back part of the nostrils, to the orbits; forming part of the palate, nostrils and orbits.

The spongy bones are four in number, two in each nostril; they are so named from their porous texture, being rolled into scrolls, and their thin laminæ of bone are pierced by many holes, which renders them very light. They are covered with the membrane of the nose, which lines universally all the cavities of this organ. The points of the lower of these bones form those projections which may be felt by the finger, and from the improper practice of picking the nose, very often serious consequences arise; for in many instances polypi of the spongy bones which are fleshy excrescences, and which can be traced to injuries of this kind, grow so as to extend down the throat, and cause suffocation and death.

The vomer, so called from its supposed resemblance to a ploughshare, is a thin flat bone; constituting the thirteenth and last bone of the upper face. It forms the lower and back parts of the

division of the nose: its upper edge is united to the base of the sphenoid-bone, and to the nasal-plate of the ethmoid: its anterior edge has a long furrow for receiving the middle cartilage of the nose; and its lower edge is joined to the maxillary and palate bones. This bone divides the nostrils from each other, and like the spongy bones enlarges the organ of smelling by affording greater space for the expansion of the membrane of the nose.

The lower Jaw.

The lower jaw consists of only one moveable bone and sixteen teeth: it is nearly of the form of a crescent, terminating the outline of the lower part of the face, forming the under part of the mouth, and serving as a frame for holding and working the lower teeth. The fore-part of this bone is termed the chin, from this its sides extend back to what are called the angles of the lower-jaw: here its base ends, and the bone bends upwards at right angles, to be articulated with the head: from these rising branches shoot out two processes or bony projections on each side; the first is called the coronoid, or horn-like process, and is intended for the convenient insertion of the temporal muscle, the lower end of this muscle being fixed into the whole of that process; and being placed at a distance before the articulation of the jaw, gives the

muscle great power in moving it. The other is the articulating process; it lies behind the former, is of an oblong shape, and set across the branch of the jaw: these articulating extremities are received into two large cavities, hollowed out in each temporal bone near the ear, and are connected to these bones, by means of capsular ligaments, which extend from one bone to the other, and enclose the joint as in a bag. Not only the surfaces of the bones composing these joints are covered with cartilage, to prevent friction, but, to render their large and pregnant motions more secure and easy, a moveable plate of cartilage is interposed, which plays between the articulating surfaces, and thus facilitates their motions. It is thin in its centre and thickens towards its circumference, by which contrivance the hollow of the joint is deepened, and the hazard of dislocation is lessened. Such moveable cartilages are generally placed in joints where frequent and rapid motion is required.

The sockets of the teeth in the lower-jaw are similar to those of the upper, but their number and size in both are various, because of the different numbers, as well of the teeth themselves, as of their roots. As the body grows, the jaw-bone slowly increases in length, and teeth are added in

proportion, till the jaws acquire their full size, when the sockets are completely filled, the lips are extended, and the mouth is said to be formed. But, in the decline of life, when the teeth fall out, the sockets are reabsorbed and carried away, as if they had never been; then the chin projects, the cheeks become hollow, and the lips fall in, the sure marks of old age.

Fractures of the lower-jaw are more or less transverse, and are known by the falling down of one part of the bone. They happen from blows or falls, but never by pulling teeth, the sockets of the teeth which alone are broken in their extraction, bearing but a small proportion to the rest of the jaw: and even in children this cannot happen, for in them the teeth have no roots, nor any hold or dangerous power over the jaw.

Of the Teeth.

The teeth of an adult are generally in number sixteen above, and as many below, though some people have more; others, fewer. The part appearing without the socket, is called the base or body, and those parts within, the roots or fangs: these roots become generally smaller towards the end farthest from the base; and are nearly conical, by which the surface of their sides lessens the

pressure made by their bases, and prevents the soft parts, at the small points of the sockets, being hurt by such pressure. Each tooth is composed of its enamel, and an internal bony substance: the enamel has no cavity or place for marrow, and is so extremely hard, that saws or files can with difficulty make an impression upon it. It is thickest upon the base, and become thinner towards the extremities of the roots: its fibres are all perpendicular to the internal substance, and are straight on the base, but at the sides are arched with a convex part towards the roots, which enables the teeth to resist the compression of any hard body between the jaws, with less danger of breaking these fibres, than if they had been situated transversely: the spongy sockets in which the teeth are placed, likewise serve better to prevent such an injury, than a more solid base would have done. The internal bony part of the teeth is of the nature of other bones; like them it is supplied with blood vessels and nerves, and like them it is subject to the disorders of other vascular parts: hence, when the enamel breaks or falls off, and the internal part becomes exposed to the air, it soon corrupts, and a carious tooth is produced, perfectly hollow within, and having only a small hole externally. The vessels and nerves enter by a small opening placed a little to the side of each root, and thence

descend to be lodged in canals, formed in the middle of the teeth; here they are employed in replacing the wasting constantly made by the attrition they undergo in manducation.

The teeth are commonly divided into three classes, viz. the incisores, canini, and grinders or molares. The incisores, so called from their use in cutting the food, are the four teeth in the forepart of each jaw: the canini derive their name from their resemblance to a dog's tusks; they are the longest of all the teeth, are placed one on each side of the incisores, so that there are two canini in each jaw, and seem to be intended principally, not for dividing or grinding like the other teeth, but for laying hold of substances: the grinders, of which there are ten in each jaw, are so named, because from their shape and size they are fitted for grinding the food. Each of the incisores and canini is furnished only with one fang; but, in the molares of the under jaw, we constantly find two fangs, and in those of the upper jaw, three fangs.

This structure and arrangement of all the teeth displays a wonderful degree of art: to understand it properly, it will be necessary to consider the under jaw as a kind of lever, with its fixed points at its articulations with the skull: that this lever is worked by its muscles; and that the aliment constitutes the object of resistance to its elevation,

In this case it will be seen, that the grinders, from being placed nearest the centre of motion, and from their uneven surfaces, are calculated to act as grinders: while the canini and incisores, being placed farther from this point, from the sharpness of their edges, and those overlapping each other as the blades of scissars do, are particularly adapted to cut and tear the food.

There are examples of children who have come into the world with two, three, and even four teeth; but these examples are very rare: and it is seldom before the seventh, eighth, or ninth month after birth, that the incisores, which are the first formed, begin to pass through the gum. The symptoms of dentition, however, in consequence of irritation from the teeth, frequently take place in the fourth or fifth month: about the twentieth or twenty-fourth month the canini and two grinders make their appearance. The symptoms are more or less alarming, in proportion to the resistance which the gum affords to the teeth, and according to the number of teeth, which may chance to seek a passage at the same time. Were they all to appear at once, children would fall victims to the pain and excessive irritation; but nature has so very wisely disposed them, that they usually appear one after the other, with some distance of time between each. The first incisor that appears is

generally in the lower jaw, and is followed by one in the upper jaw. Sometimes the canini, but more commonly one of the grinders, begins to pass through the gum first. These twenty teeth, viz. eight incisores, four canini, and eight grinders, are called temporary or milk teeth, because they are all shed between the age of seven and fourteen, and are succeeded by what are called the permanent or adult teeth; and which are of a firmer texture, and have longer fangs: these adult teeth being placed in a distinct set of alveoli or sockets, the upper sockets being gradually removed as the under ones increase in size, till at length the temporary, or upper teeth, having no longer any support, fall out. To these twenty teeth, which succeed the temporary ones, twelve others are afterwards added, viz. three grinders in each side, in both jaws: and in order to make room for this addition, we find that the jaws gradually lengthen, in proportion to the growth of the teeth; so that with twenty teeth they seem to be as completely filled, as they are afterwards with thirty-two: this is the reason why the face is rounder and flatter in children than in adults. In extreme age the teeth drop out, their sockets are removed also, and the face again shortens.

With regard to the formation of the teeth, we may observe, that in a fœtus of four months the

alveolar process appears only as a shallow longitudinal groove, divided by minute ridges into a number of intermediate depressions; in each of which we find a small pulpy substance, surrounded by a vascular membrane. This pulp gradually ossifies, and its lower part is lengthened out to constitute the fang. When the bony part of the tooth is formed, its surface begins to be incrusted with the enamel. The rudiments of some of the adult teeth begin to be formed at a very early period, for the pulp of one of the incisores may generally be perceived in a fœtus of eight months, and the ossification commences soon after birth.

The Bone of the Tongue.

There is a small bone, nearly of the figure of the lower-jaw bone, and which though not classed with those of the head or trunk, yet as being situated near to the head, we shall describe before we come to those of the trunk. This bone corresponds in place with the chin, below which, about an inch, it may be felt, the uppermost of the hard points in the fore part of the throat: where being placed horizontally, it lies immediately between the root of the tongue and the upper part of the wind-pipe, and carries upon it a valvular cartilage, for shutting the passage and preventing any thing getting down this tube; while its legs extend along the

sides of the throat, keeping the openings of the wind-pipe and gullet extended, as we would keep a bag extended by two fingers. This bone is the centre of the motions of the tongue, for it is the origin of those muscles which compose chiefly the bulk of the tongue; of the motions of the wind-pipe, for it forms at once the top of the wind-pipe and the root of the tongue, and joins them both together; of the motions of the gullet, for its legs surround the upper part of the gullet, and join it to the wind-pipe; and it also forms the centre for all the motions of the throat in general: for muscles come down from the chin to this bone, to move the whole throat upwards; others ascend from the breast, to move it downwards; while different muscles come from the sides to move the throat backwards.

OF THE
TRUNK OF THE HUMAN BODY.

THE trunk of the human body comprizes the spine, the pelvis, and the thorax or chest.

The Spine.

The spine or back-bone is that long chain of bones which extends from the skull to the end of the loins. It consists of twenty-four distinct bones, named vertebræ, from the Latin word *vertere* to turn; because they perform at certain points the chief turnings and bendings of the body: they also form a tube or canal along the whole length of the spine, for lodging and defending from harm the spinal marrow; and they support the whole weight of the trunk, head, and arms, without suffering under the longest fatigue, or the greatest load, which the limbs can bear. Hardly any thing can be more beautiful or surprising than this mechanism of the spine, where nature has established the most opposite and inconsistent functions in one set of bones; for their motions are so free as to turn continually, yet so strong as to support the whole weight of the body; and so flexible as to bend quickly in all directions, yet so steady within as to contain and defend a material and very delicate part of the nervous system.

The vertebræ are divided into those of the neck, back, and loins, and the number of pieces corresponds with the length of these divisions. The vertebræ of the neck are seven in number; their form is simple, they being almost like rings, their processes scarcely project; they are very loose and free; and their motions are the widest and easiest of all the spine. The twelve immediately below these are the vertebræ of the back; they are larger and stronger than the former, and their processes project obliquely downwards, so as to be laid over each other: hence one bone is fastened to the other, which, together with their connection with the ribs, renders this the steadiest part of the spine, and allows it only a very limited motion. The vertebræ of the loins are the next and the last; they are five in number; they bear the whole weight of the body, and perform the chief motions of the trunk, and with this view, nature has made them the largest and strongest of the entire vertebræ, and given them a wide and free arrangement of their processes.

The form of each vertebra is particularly calculated for producing the different uses of the spine, and displays at once the astonishing designs and execution of the supreme architect. The spine is intended as a support to the trunk, head, and arms; for this purpose each vertebra

is composed of a main part, called its body, which is a thick, spongy, and therefore light bony substance, convex before, concave at the back part, and almost horizontal upon its upper and under sides, when it is joined to similar bodies of the other vertebræ. All these bodies are connected together, like the sections of a large cane, and constitute a bony pillar for sustaining the upper parts of the body: but, besides support, these parts require motion: hence, this pillar is furnished with all the means of producing it: first, then, we see it divided into many pieces; having a perfectly elastic substance interposed between every two bodies, and which by easily yielding to whatever side we bend, and afterwards, by a powerful resilition, returning to its place in a moment, takes off pressure from the delicate nervous column, and thus preserves it from injury in the violent and sudden motions of the body. During the day this elastic substance is continually yielding to the pressure, so that we are an inch taller in the morning than at night; we are shorter in old age than youth; and the aged spine is bent forwards, owing to the yielding of this part.

Next, we observe projections standing out from the back-part of the spine for different purposes. The first are the articulating processes, of which the body of each vertebra furnishes four; they

grow out obliquely, two from the upper and two more from the under part of each body, and incline towards those of the other vertebræ, till they meet to be articulated ; when they serve the double purpose of fastening together, and securing, in conjunction with the intervertebral substances, the different pieces of the spine; and also, by affording so many moveable joints, of assisting in its motions.

From between these superior and inferior articulating processes, the body of each vertebra sends out two arms, which, meeting behind, form an arch or canal for the spinal marrow; and from the middle of that arch, and opposite to the body, another process, called the spinous projects. These processes have their direction backwards, and from the sharpness of their points, which form the ridge of the back, give the name of spine to the whole column. They are intended to serve as so many handles and levers for moving the spine: their size enabling the muscles to take a firm hold, while their length gives those muscles a powerful force in extending and raising the spine. But, beside these, there are other processes, which, from their direction, are called transverse processes, because they stand out at right angles, or transversely, from the body of the bone: they grow out from the sides of the arms or branches

which form the arch for the spinal marrow, and are two in number to each vertebra. They also serve as levers, and long and powerful ones, in moving and turning the spine.

Thus we see that each vertebra consists of a body and seven processes; but it must be understood, that this is not the case with all the vertebræ. As we observed before, the vertebræ of the neck are very indistinctly marked, and the first two materially differ from the general character, for the purpose of adopting a most beautiful piece of mechanism.

The first vertebra of the neck is named atlas, from the globe of the head being immediately placed upon it. Its processes are scarcely distinguishable; it has no body; and is simply a ring, through which the spinal marrow passes from the great hole of the skull into the rest of the tube, formed for its reception. The atlas is articulated at two points, one on each side, with the occipital bone of the skull, and these joints being strictly hinge-like, enable the head to move backwards and forwards, but allow it no motion to either side. This motion, called the rotatory, is performed by means of a tooth-like process, which rises from the upper part of the body of the second vertebra of the neck, and which forms the chief characteristic of that bone. This process is about an

inch in height, resembling in some degree the little finger, stands perpendicularly upwards, passing through the ring of the atlas, and serves as an axis, on which this bone, and with it the head may perform all the rotatory motions. It is confined by ligaments, one of which connects its front with the edge of the occipital hole, and the other, extending from one side of the atlas to the other, embraces the tooth-like process, and prevents its injuring the spinal marrow. When this ligament is burst by violence (as has happened) the tooth-like process breaks loose, and pressing upon the spinal marrow, the person dies.

All the vertebræ conjoined, make a large canal of a triangular or roundish form, for lodging the spinal marrow, and which, as it descends, gives off its nerves to the neck, arms, and legs: and the whole course of this canal is rendered safe and smooth by living membranes, which serve the double purpose of connecting the different bones together, and also of affording a soft and easy sheath to the marrow.

Thus we see that a vertebra consists of different parts, all admirably suited to produce their various purposes: its body helps to form the pillar for sustaining the upper parts of the frame: the intervertebral cartilages, which are placed between the different bodies, being of a highly elastic nature,

admit motion and prevent concussion: while the numerous processes, which grow out from the bone behind, act as so many handles and levers, by which the muscles move and work the spine; and also serve to form the tube or canal for containing the spinal marrow.

Of the Pelvis.

To give a steady bearing to the trunk, and to connect it with the lower extremities, by a sure and firm joining, the pelvis is interposed. It is a circle of large and firm bones, standing as an arch betwixt the lower extremities and the trunk: its arch is wide and strong, so as to give a firm bearing to the body; its individual bones are large, so as to give a deep and sure socket for the implantation of the thigh-bone: its motions are free and large, bearing the trunk above, and rolling upon the thigh-bones below; and it is so truly the centre of all the great motions of the body, that when we believe the motion to be in the higher parts of the spine, it is either the last vertebra of the loins bending upon the top of the pelvis, or the pelvis itself rolling upon the heads of the thigh-bones.

The pelvis, so named from its partly resembling a basin in its form, is constructed, in the adult, of four large bones, of the os sacrum behind, the ossa

innominata on either side and before, and the os coccygis below.

The os sacrum or hinder bone is the base, on which the spine, and consequently the whole body, rests, its upper surface being articulated with the under one of the last vertebra of the loins. It is of an irregular triangular shape, broad above for supporting the trunk; narrow below; convex behind; and concave before; it guards the nerves proceeding from the end of the spinal marrow, and also forms the back-part of the pelvis. Within this bone, there is a triangular cavity, which is a continuation of the canal of the spine; here the spinal marrow ends, and branching into a great many thread-like nerves, has the form of a horse's tail, and is therefore named cauda equina. These nerves afterwards go out by five great holes, which are on the fore-part of the bone, to be distributed to different parts.

The os coccygis is a continuation of, or rather an appendage to, the sacrum; it consists of four bones in middle age, each bone becoming smaller, as it descends, till the last ends almost in a point, and by bending inwards serves to contract the lower opening of the pelvis, so as to support effectually the viscera within. These two bones, the sacrum and coccygis, are described by most anatomists as

parts of the spine, and certainly not without reason. They are a continuation of that chain of bones, and perform some of their functions; supporting, like them, the weight of the body, lodging the spinal marrow, and transmitting some of its nerves; but, as they are precluded motion, (for which reason they are distinguished by some anatomists, from the true or motionary part of the spine, by the title of false vertebræ,) and as they are closely locked in between the other bones of the pelvis, so as to constitute a principal share of this basin, at its hinder part, we thought it adviseable to class them as bones of the pelvis in the description.

The sides and fore-part of the pelvis, as we before observed, are composed of two bones, which correspond in size and figure with each other, but, being of a most irregular shape, are called the ossa innominata, or nameless bones. In children each of these bones consists of three separate pieces, but which afterwards, when greater strength is acquired, and ossification is become more perfect, are so firmly united as to form but one bone; still these bones continue to be described as though each consisted of three pieces.

The os ilium, or haunch-bone, is the highest, constituting each upper side of the pelvis, and has its posterior edged firmly and immoveably articu-

lated to that of the os sacrum. It forms the flank, and is the largest division of the os innominatum.

The os ischium, or hip-bone, lies perpendicularly under the former, and is the lowest point of the pelvis, upon which we sit.

The os pubis, or share-bone, is the last and smallest piece of the three, forming the fore-part of the pelvis, and completing its brim.

Each os innominatum has a cup-like hollow for the head of the thigh-bone to move in. It is formed at that part where the three original pieces, which we have described, meet, to form one bone, and is called the acetabulum, from its resemblance to a measure which the ancients used for vinegar.

The pelvis is intended for many great purposes in the human frame: first, it is the base for supporting the superior parts of the body: next, it is so constructed as to receive into its sockets, and to roll upon the heads of the thigh-bones, by which means it connects the lower extremities with the upper parts of the frame, without precluding motion; and, lastly, by forming a kind of basin at the lower end of the trunk of the body, it helps to sustain its viscera; while its outside surfaces, its ridges, and projecting points, serve as so many convenient places for the origin and insertion of numerous muscles, which, having one of their extremities fixed into the pelvis, as into a kind of

circular basis, perform by means of it, with the advantage of a lever, some of the motions of the trunk, and many of those of the lower limbs.

Of the Thorax.

The thorax or chest is that large cavity reaching from the neck to the lower end of the breast-bone before, but extending farther downwards at the back, and including all that space which lies between the opposite ribs. It is intended to afford a secure and commodious residence for the heart, lungs, &c. and is formed, behind, by the twelve dorsal vertebræ of the spine; at the sides, by the ribs; and by the breast-bone, before.

The Ribs.

The ribs form the sides of the chest, covering and defending the heart and lungs; and they also assist in breathing, being joined to the spine by regular hinges which allow of short motions, and to the breast-bone by cartilages, which yield to the motion of the ribs, and return again from their elastic nature when the muscles cease to act. They are generally twelve in number on each side, though frequently eleven or thirteen have been found: those whose cartilages are separately inserted into the breast-bone are called the true ribs, and are seven in number; while the five

lower ones, whose cartilages do not reach that bone, but run into each other, and are joined to it by a common cartilage, are designated by the name of false ribs. The lower edge of each rib is furrowed along its internal side for the safe passage of the intercostal vessels and nerves, and to the ridge, at each side of this canal, are fixed the double rows of intercostal muscles.

The Sternum.

The sternum, or breast-bone, is commonly composed of three bones, joined together by cartilages: it extends from the upper to the lower part of the breast anteriorly, and has the ends of the ribs and collar-bones articulated with it, by which the cavity of the chest is completed, as far at least as the bones are concerned.

This bone, the ribs, and indeed all the chest, stand so much exposed, that did we not guard them with the hands, fractures must be very frequent: but, when they are broken and beaten in, they hurt the heart or lungs, and not unfrequently the most dreadful consequences ensue. Often, by a wheel passing over the body, the breast-bone is broken; its pieces press inwards upon the heart, which is sometimes burst; but more commonly the patient dies a slow and painful death; for the inflammation, which begins in the place of the

wound, is extended to the lungs; is propagated still onwards to the heart; which being once inflamed, brings on anxiety, oppression, faintings, and palpitations; then anxious breathing, quick and interrupted pulse, still more frequent faintings, and lastly death. But the ribs, covering more properly the lungs, do not always produce death by their fractures, for the wound by the point of a rib is no deeper than just to puncture the lungs; yet through this small wound on their surface, the lungs breathe out their air into the cavity of the chest, and at last it escapes under the cellular substance of the skin, when the man is blown up to a prodigious degree, with continually encreasing anxiety; his breathing becomes more and more interrupted, and, if not assisted, he must die.

Having now described the bones which form the trunk of the body, we next come to those of the limbs, and first to the bones composing the upper limbs.

OF THE

SUPERIOR EXTREMITIES.

Each superior extremity consists of the shoulder, arm, fore-arm, and hand.

The Shoulder.

The shoulder includes two bones, the clavicle and scapula. The clavicle or collar-bone is placed at the root of the neck, and at the upper part of the breast; it lies almost horizontally, and extends across from the tip of the shoulder to the upper part of the breast-bone: its figure is long, round, and curved like an italic *s*, and it serves to the shoulder as a kind of arch, supporting and preventing it from falling in and forwards upon the breast, by which the motions of the arms would be confined, and the chest made narrow, which must have been the case, had these bones been wanting. The collar-bones also make the hands strong antagonists to each other, and which without this steadying, they could not have been.

The scapula, or shoulder-blade, is the other bone of the shoulder: it is a broad, flat, triangular bone placed upon the outside of the ribs, and serving as a base to the whole superior limb. Its under side is somewhat concave, to match the convexity of

ribs, yet it is not in immediate contact with them, but is separated from them by several layers of muscular flesh; so that this bone may glide upon the trunk, and increase the motion of the limb which is suspended from it. For this reason the scapula is not articulated with any bone of the trunk, or connected to it by ligament, as such connexions must impede the freedom of its motions; but it is securely held to the trunk by those very muscles which perform its movements. The arm-bone is articulated with the scapula, at one of its angles; this angle terminates in a flat surface, not more than an inch in diameter, for receiving the head of that bone, and as it is very shallow, luxations of the shoulder are more frequent than of any other joint. A high ridge, called the spine, rises from the back or external surface of the scapula, and traversing its whole length, runs forward to terminate in that high point or promontory which forms the tip of the shoulder, and overhangs and defends the joint. This projecting point of the scapula is called the acromion process; it almost makes a part of the shoulder joint, preventing luxation upwards; and is the part which is articulated with the collar-bone. There is also another process which stands out from this angle of the scapula, and is intended to secure the joint, and prevent dislocation like-

wise: it is a thick, short, but crooked process, and is calculated to defend the joint at its inner side. But the principal strength of this articulation arises from the muscles, which, passing from the shoulder-blade over the joint, are inserted into the arm-bone close to its head: these muscles in their passage, closely embrace the head of the arm-bone, adhere to the capsular ligament which encloses the joint, and, by spreading themselves over it, thicken and increase its strength; and they also by their contraction hold the arm-bone in its place.

The shoulder-blade, as we before observed, is not fixed, but moves upon the trunk; it therefore serves as a moveable intermediate base to the whole arm which hangs from it. For this purpose it is firmly held to the trunk by numerous and strong muscles, which can move it in various directions, and, by a quick succession of these movements, can carry its whole body in a circle, by which greater scope is given to the motions of the arm. This bone also serves to cover and defend the back-part of the chest.

The Arm.

The arm is commonly divided, in the description, into two parts, which are articulated with each other at the elbow. The upper part, or os humeri, retains the name of arm, properly so called, and the lower part is usually termed the fore-arm.

The arm then is that division extending from the shoulder to the elbow: it has only one bone, which is long, round, and nearly straight, and which is articulated at the shoulder by its round head being received into the hollow of the shoulder-blade, and connected thereto by ligaments, which enclose the whole joint as in a bag. But that this joint may have the freest motion, the hollow for receiving the arm-bone is extremely shallow, so that its round head might easily turn in all directions; and the connecting ligaments, for the same reason, are longer than in other joints. Then, as in all other moveable articulations, not only is the head of the arm-bone tipped with cartilage, but the surface of the cavity into which it is received is also lined with the same substance, for the purpose of preventing concussion and friction; and the more effectually to preclude the latter, an oily fluid is constantly moistening the whole internal surfaces of the joint, and which is supplied from the inner side of the capsular ligament, and also from soft, spongy substances, which are placed within the joint. The lower end of the arm-bone is articulated with the bones of the fore-arm, at the elbow, carrying them with it in all its motions, and serving as a base on which they perform their peculiar movements.

The Fore-arm.

The fore-arm is composed of two bones, viz. the ulna and the radius. The ulna, so named from its having been used as a measure, is the longer of the two bones, and is extended from the wrist on the side of the little finger to the point of the elbow, where it assumes a hook-like form; the concave side of which being fitted to the pulley-like surface of the lower end of the arm-bone, produces the motions of flexion and extension, so that the fore-arm may be bent to a very acute angle, or extended to almost a straight line with the arm.

The radius is the second bone of the fore-arm: it is but partially articulated with the end of the arm-bone, and has its position reversed with that of the ulna: for the ulna, belonging principally to the elbow, has its greater end upwards; the radius principally belonging to the wrist has its greater end downwards; and while the ulna only bends the arm, the radius carries the wrist with a rotatory motion, and for this purpose it is so articulated with the ulna at the ends, the only points where these bones meet, that it turns upon it in half circles. The two bones are connected together along their whole length by a strong ligament, which extends from one to the other, filling up the vacant spac between them, and rendering

their position the more secure. The radius is hollowed at its lower end for receiving the bones of the wrist in articulation, but the ulna does not reach quite so far as to come in contact with those bones.

The Hand.

The hand comprehends all from the joint of the wrist to the ends of the fingers: its back-part is convex for greater firmness and strength: and it is concave before for containing more conveniently such bodies as we take hold of.

Anatomists generally divide the hand into the carpus or wrist-bones; the metacarpus, or bones that stand upon the wrist, and serve as a basis to the fingers; and the fingers, consisting each of its three joints.

The carpus or wrist is composed of eight small bones, disposed in two rows: those of the upper row form an oblong head, to be articulated with the cavity of the radius of the fore-arm, so as to allow motion on all sides, and by a quick succession of these motions the hand may be moved in a circle. The lower row is articulated with the bones of the metacarpus, to which they serve as a solid foundation or centre. These small bones are firmly tied to each other by strong ligaments: there are two in particular which deserve notice; one is situated on the external, the other on the internal side of the wrist, and both not only help

to strengthen the parts on which they lie; but also confine and serve as smooth lubricated sheaths to the tendons which pass under them.

The metacarpus consists of four long round bones for sustaining the fingers: they are founded upon the wrist bones; but departing from them as from a centre, in somewhat of a radiated form, they allow the fingers a freer play: these bones are connected to each other by plain surfaces, and are tied at their lower ends by ligaments, which prevent their being drawn asunder. They consequently have not a large motion.

The Thumbs and Fingers.

The thumb and four fingers are each composed of three bones. The thumb is placed obliquely with respect to the fingers, and its bones are thicker and stronger than those of the former, which is necessary, as the thumb is intended to counteract all the fingers. All the bones of the fingers are placed in three rows, called phalanges. The first phalanx is articulated with the bones of the metacarpus, and consists of the largest bones; the second stands out from the first; and the last phalanx grows out from the second and completes the fingers. These different bones composing the fingers are all regularly jointed with each other, and in such manner as to allow not only a hinge-like but also a rotatory motion.

OF THE

INFERIOR EXTREMITIES.

Each of the lower extremities comprises the thigh, the leg, and the foot, and has a great analogy in the structure and distribution of its parts with the upper extremities.

The Thigh.

The thigh, like the arm, has only one bone, which is the longest in the whole body, and the largest and strongest of all the round bones: its upper end inclines inwards, and swells into a large, smooth, round head, to be articulated with the cavity, which is afforded by the side bones of the pelvis. Juſt below this head the bone becomes small, whence this part is called its neck. The articulation of the thigh bone with the trunk is secured by strong ligaments; the first is almost peculiar to this point, and is called, from its shape, the round ligament: it grows out of the articulating cavity, and is inserted directly into the head of the bone: the other is the capsular ligament, which arising from the rim of the articulating cavity of the pelvis, passes over the whole joint, embraces the head of the thigh-bone as in a purse, and is inserted into this bone at its neck. The body of the thigh-bone continues thick and strong

down to its lower end, where it spreads with two great protuberances, called condyles, to be articulated with the bones of the leg. This bone not only serves as a fixed point for performing several motions of the trunk, which it sustains like a pillar, but it also affords a base for the leg to carry on its own motions, and is principally concerned in walking, running, &c.

The Leg.

The leg is composed of three bones; two long ones, called tibia and fibula; and a small one placed at the knee.

The tibia, so called from its resemblance to an old musical pipe, is the long triangular bone at the inside of the leg; it runs nearly in a straight line from the thigh-bone to the ankle, supporting the whole weight of the body, and has its upper end expanded into a large surface for receiving the lower end of the thigh-bone, and forming the knee-joint. This articulation admits flexion and extension, and is secured by very strong ligaments; to compensate for the weakness of its boney structure, arising from the flatness of the articulating surfaces. The joint not being protected as in other cases by a ball and socket, by a large head imbedded in a deep cavity, by overhanging bones, or by hook-like projections, all which

were contrivances ill adapted to its motions. In this instance the strength and complexity of the ligaments are the resources which have been had recourse to. At the sides of the joint the capsular ligament is peculiarly strong. The contrivance of a ligament within the cavity of the joint, and directly connecting the two bones, is improved upon by a striking adaptation to the necessities of the case. Instead of one, there are two such ligaments which cross each other, and hence are named "crucial ligaments;" and by a varied tension of each in different positions of the joint, they check its motions, and secure its safety.

This, however, is not all that is admirable in the mechanism of this curious joint. On the top of the tibia are placed two moveable cartilages of a crescent-like form. Their outward edges are thick, while their inward borders are extremely thin, and they thus form a hollow in which the protuberances of the thigh bone play with security, and with a facility that is much increased by their loose connections.

Hence it follows that although this joint be the most oppressed by great loads; and the most exercised in continual motions; yet it is less frequently displaced than any other. The lower end of the tibia is articulated with the foot, and forms the inner ankle.

The fibula is a long slender bone placed at the outside of the tibia: its head is connected to that bone by ligaments, but does not reach high enough to enter into the composition of the knee-joint; it lies along-side the tibia, somewhat like a splint, encreasing the strength of the leg, and, like the double bone of the fore-arm, also completing its form. This bone descends to the foot, where it forms the external ankle, and is connected to the tibia, along its whole length, by a broad, thin ligament, similar to that which is found between the bones of the fore-arm.

The knee-pan is the third and last bone of the leg. It is a small thick bone, of an oval, or rather triangular form. The basis of this triangle is turned upwards to receive the tendons of the great muscles which extend the leg, the pointed part of this triangle is turned downwards, and is tied by a very strong ligament to the upper part of the tibia, just under the knee. The patella or knee-pan is intended as a lever; for by removing the direction of the extensor muscles of the leg farther from the centre of motion, it enables them to act more powerfully in extending the limb: to facilitate its motions, its internal surface is smooth, covered with cartilage, and fitted to the pulley of the thigh-bone, upon which it moves.

The Foot.

The foot, like the hand, is divided into three parts, viz. the tarsus or instep, the metatarsus, and the toes.

The tarsus or instep is composed of seven bones, firmly bound together by ſtrong ligaments; and forming a sure and elastic arch for supporting the body. The uppermost of these bones, called the astragalus, is articulated at its superior surface with the bones of the leg in such manner, as to afford the motions of flexion and extension in the ankle joint; while the sides of this bone are overlapped by the two processes which descend from the tibia and the fibula, to form the internal and external ankles so completely, as to secure the joint from dislocations. The astragalus is joined below to the os calcis, and serves as the immediate base for supporting the bones of the leg. The os calcis or heel-bone is the largest of the seven bones: behind, it projects out into a large knob called the heel, for receiving the insertion of the tendon of achilles. It is situated under the astragalus, with which it is so firmly connected as scarcely to admit motion, but which renders this principal part of our base, which rests on the ground, secure and firm: its lower surface is pressed flat

at the back-part, by the weight of our bodies, this bone being the basis of the whole frame.

The tarsus or instep is convex above, but leaves a concavity below for lodging safely the several muscles, tendons, vessels, and nerves, that lie on the sole of the foot; and being composed of several bones, all having slight movements with each other, and firmly tied together by ligaments, so as to prevent dislocation, is calculated to afford a sufficient elasticity for precluding shocks in walking, running, or the other motions of the body: and also for security against fractures, which it would have been liable to had the tarsus been composed of only one bone.

The metatarsus is composed of five bones, which correspond in their general character with the metacarpal bones of the hand; but are longer, thicker, and stronger than the latter. The bases of these bones rest upon the tarsus or instep; while their extremities support the toes, in like manner as the metacarpal bones sustain the fingers. When we stand, the fore-ends of these bones and the heel-bone are our only supporters.

The Toes.

Each of the toes, like the fingers, consists of three bones, except the great toe, which has only two bones: those of the other four are distinguish-

ed into phalanges. In walking the toes bring the centre of gravity perpendicular to the advanced foot.

The Sesamoid Bones.

There are small bones found in different parts of the human body, and which, from their resemblance to the seed of the sesamum, obtain their name. They are nothing more than portions of the ligaments of joints, or of the tendons of muscles become bony by pressure; and are uncertain both in their number and situation.

Retrospect of the Skeleton.

When the bones of an animal are connected together, after the soft parts have been removed, the whole is called a skeleton: on its dimensions pend the height, ánd, in a great measure, the breadth, and strength of the human body. Had this frame been constructed of fewer bones, our actions must necessarily have been rendered constrained, and less convenient: we find it therefore wisely divided into numerous pieces, for enlarging the sphere of motion; while all its divisions are peculiarly and admirably fitted to the various uses for which they have been designed.

The head, we have seen, to form a spheroidal case for lodging and defending the brain within

its cavity, while its elevation above the rest of the body places the seat of the soul in a position, at once commanding, and the best suited to her superior attributes. In the head and contiguous to the emporium of sense, we also see situated the organs of sight, hearing, smelling, tasting, and of speech; the more rapidly to transmit information to the brain, and also to obey its commands.

From the head, we see descending a large chain of bones, called the spine, or back-bone, and reaching down to the extremity of the pelvis. This bony pillar not only supports the head, and superior parts of the body, but also affords a canal along its descent for safely lodging that continuation of the brain called the spinal marrow; and being divided into several small bones, connected together by elastic substances, and having a great number of processes projecting like so many small handles, for the muscles to take hold of and work by, it allows the neck, back, and loins, a sufficient motion.

From the upper part of the spine, the ribs extend out on each side, and meeting at the breast-bone before, they form the cavity of the chest for lodging and defending the heart, and the organs of respiration.

The lower part of the spine, supporting all the parts of the body which are superior to it, is itself

received in a wedge like form, and supported by the bones of the pelvis. These bones are so constructed as to serve at the extremity of the trunk not only as a kind of basin, for sustaining some of its viscera, as the intestines, &c. but also, as a medium of connection between the body and the lower extremities, affording a firm and safe support to the former, and producing the necessary motion at the hip-joints, by rolling upon the round heads of the thigh-bones.

In viewing the superior extremities, we observe, that the base of each is placed in a situation, the best calculated for the limb to perform all its motions, and at the same time, to defend from injuries the head and chest; while the muscles which are necessary to work the limb, serve as a defence and covering to the vital parts within the ribs. The division of each extremity into several bones, and their peculiar connexions, are intended to produce large motion: that at the shoulder is sufficiently free for describing a circle; at the elbow the arm may be bent to an acute angle, whilst the wrist is capable of much motion; as are the thumb and fingers; the whole limb producing a collective motion sufficiently great for all the purposes of necessity and convenience.

The inferior extremities we also see divided into several bones, and for the purposes of motion;

but serving as two moving columns for the support and carriage of the rest of the body, they are necessarily stronger, and their joints firmer and more confined: hence the thigh-bone has less motion than that of the arm: the joint of the knee is stronger than that of the elbow: and the motion of the ankle and toes is slower, but more firm than that of the wrist and fingers.

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EXPLANATION OF PLATE I.

FRONT VIEW OF THE SKELETON.

Head and Neck.

1. The Frontal-bone, forming the Forehead.
2. One of the Parietal-bones.
3. One of the Temporal-bones.
4. The left Cheek-bone.
5. The Upper Jaw.
6. The Lower Jaw.
7. The Teeth, imbedded in their bony cavities formed by the alveolar processes.
8. One of the Sutures separating the Bones of the Head: the Coronal.
9. The Bodies of the Vertebræ of the Neck, which are separated from eachother in the living Subject by an elastic Body: the Intervertebral Substance.
10. The Transverse Projections from the Vertebræ for the attachment of Muscles, that they may act with the Advantage of Levers; these are seen more distinctly projecting from the lumbar Vertebræ.

The Trunk.

11. The Sternum or Breast-bone.
12. The Ribs, 7 true and 5 false Ribs.
13. Their Cartilages, connecting them with the Sternum, and which replace the Ribs by their elasticity when they are elevated by inspiration.
14. The Vertebræ of the Loins with their transverse Proc esses.
15. The Bones of the Pelvis; the Sacrum is a broad base to the central pillar of the body, and is seen in shadow; the Ossa innominata, are seated at the sides and the fore-part of the Pelvis: they are divided into
    a. The Tubis.—*b*. The Ischium.—*c*. The Ilium.

Upper Extremity.

16. The Clavicle or Collar-bone.
17. The Scapula or Blade-bone, which is seen in the next Plate.
18. The Humeous or Arm-bone.
19. The two Bones of the Fore-arm.
    a. The Radius, on which the Arm turns when the palm of the Hand is placed flat upon a table, or the reverse.
    b. The Ulna.
20. The 8 Bones of the Carpus or Wrist.
21. The Bones of the Thumb.
22. The Metacarpus, which forms the Palm and the back of the Hand, and the Finger-bones.

Lower Extremity.

23. The Thigh-bone.
24. The Patella or Knee-pan.
25. The two Bones of the Leg.
    a. The Tibia.—*b*. The Fibula.
26. The Inner Ankle formed by a projection of the Tibia.
27. The Metatarsus.
28. The Toes.

EXPLANATION OF PLATE II.

BACK VIEW OF THE SKELETON.

1. The Parietal-bone joined to its fellow by the sagittal suture.
2. The Occipital-bone, which is pierced with a round hole, through which the Spinal Marrow is connected with the Brain by the Medulla Oblongata; it is not seen in this view.
3. The 7 Cervical Vertebræ.
4. The 5 Lumbar Vertebræ. Those Vertebræ which occupy the middle of the Spine, and to which the Ribs are attached, are the 12 Dorsal. The Upper and Lower Vetebræ admit of a freer motion with each other than the Dorsal, whose overlapping processes bind one to the other. Strength was here of more importance than a range of motion.
5. The Bones of the Pelvis—the Sacrum is seen in front.
6. The Os Ilium.
7. The Ischium on which we rest in sitting. The third Bone assisting to form the Ossa Innominata, namely the Pubis is not seen in this plate.
8. The Os Coccigys is a small incurvated Bone below the Sacrum, bending inwards to support the soft contents of the Abdomen.
9. The Ribs jointed with the Vertebræ.

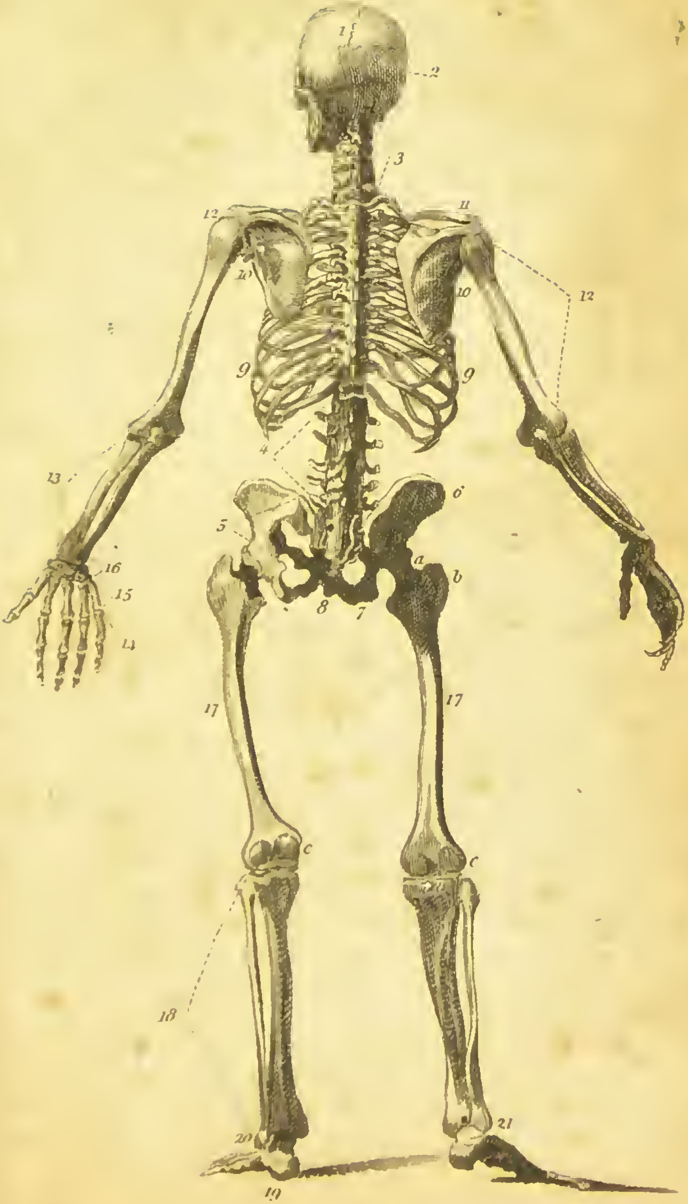
Upper Extremity.

10. The Blade-bone, which moves with the Arm.
11. The Clavicle projecting the Arm from the Trunk.
12. The Arm-bone with its round Head in a shallow depression of the Blade-bone.
13. The Fore Arm formed by its 2 Bones.
14. The Fingers.
15. The Metacarpus, forming the back of the Hand.
16. The Carpus, forming the joint of the Wrist.

Lower Extremity.

17. The Thigh-bone.
    - *a.* Its Neck terminated by a round head deeply imbedded in a hollow of the Os ennominatum.
    - *b.* A large protuberance for the attachment of powerful muscles the great Trochanter.
    - *c.* The heads of the Thigh-bone articulated with those of the Tibia.
18. The two Bones of the Leg.
19. The Heel-bone, on which we stand.
20. The Bones of the Tarsus, forming the Instep.
21. The outer Ankle formed by a projection of the Fibula, as the inner one is by the Tibia, and both together making a deep semicircular hollow for a strong hinge-like joint.

Plate



OF THE

MUSCLES.

Having finished the description of the bones, we now come to those organs which move the bones, and put the whole frame into motion. These organs are called muscles, and constitute all that part of the human body known by the name of flesh. Each large muscle consists of two distinct portions, namely, its belly, which is the only part that is active, and its thin cordy fibrous and shining extremities, or tendons: the only purposes of the last are to fix the muscles to the moveable parts in a concentrated form; in consequence of which, a greater power is permitted to act, as labours are assisted by ropes in moving weighty bodies; hence they are principally employed in implanting muscles upon bones, and are not discoverable in the heart, stomach, intestines. Muscles are universally the organs of motions in animals, although we cannot always detect their peculiar structure in some of the minuter organs, and still less are we able in the smaller animals. Yet as their motions are regulated by the same laws as those which influence muscular irritability, we may infer that they depend on that as a cause.

The whole fleshy portion, then, of the human body consists of a great number of muscles, or

distinct fleshy bundles, whose surfaces, although in contact, are still separate, sliding over each other, in their alternate contractions and elongations; and having both ends fixed into the parts which they are intended to move. They are of different sizes and shapes, according to the degree of force required from them, and the form of the part on which they are situated: hence those on the body are mostly broad and flat, while the muscles of the extremities are of a long, round figure, with tendinous ends.

Each muscle performs its action by contracting both ends towards the centre, when one of these ends, serving as a fixed point, the other, with the bone to which it is affixed, is necessarily drawn towards it; and thus, by the co-operation of several muscles, the movement of the limb, and even of the whole body, is effected: as soon as the motion is accomplished, the muscles, which performed it, relax, and allow their ends to elongate to their former position.

The structure of a muscle appears to consist of a number of long soft fleſhy fibres, and lying parallel with each other; and these fibres being enveloped in a thin cellular membrane, are fastened by it into little bundles, which are again tied by some of the same membrane into larger bundles, until the whole muscle is produced; but, though

this is the apparent structure of the muscle, still its ultimate division is unknown; that which appears to the eye to be an elementary fibre, being discovered, by the help of glasses, to consist of a bundle of fibres.

In this very general description of muscles the form and appearance of those larger ones which cover our bones have been kept more particularly in view. But it would convey a very imperfect idea of their extent and importance to confine our observations to them: muscular fibres, in fact, enter into the structure of almost every organ where motion is necessary, and are adapted in their form and size to that of the parts to which they are attached. The heart and blood-vessels; the stomach and intestines; the bladder, &c. are composed, in a great measure, of very minute muscular fibres stretching longitudinally, or transversely, or obliquely, and sometimes in all directions; often so small are they that we can only discover their structure by our glasses, and not unfrequently they escape our detection altogether, otherwise than by justifiable inferences, from observing that the same laws regulate their motions with those which influence the larger muscles.

The further consideration of these organs we shall defer until we come to speak of muscular motion: and shall now take a rapid view of the

different muscles which move the human body: first, however, observing, that excepting a few, the whole of the muscles are in pairs; or, in other words, that those situated on one side of the frame have corresponding muscles on the other: and indeed it may not be improper here to observe, that if an exact section of the whole human body were made, from the top of the head to the lower end of the trunk, the divided sides would be found similar in structure and parts to each other, the contents of the breast and abdomen only excepted, and which from their nature and situation do not admit of equal division.

We should here also observe, that the end of the muscle, which forms its more fixed point, is called its origin; while the other end, which is fastened to the bone to be moved, is termed its insertion: and likewise, that the shape and turn of the part, particularly of the limbs, depend principally upon the size and proportions of the muscles which are situated thereon. Thus we see many of them taper into long slender tendons, where a decrease of size is necessary and beautiful, as at the small part of the fore-arm and leg; while others swell out in symmetrical proportion, and give the appearance of fulness and strength to other parts of the frame.

Muscles of the Head.

The fore-head is wrinkled and drawn upwards, as are also the eye-brows, by a broad thin muscle, which rises at the back-part of the skull, and covering the head, runs down the forehead, to be inserted into the skin of the eye-brows.

The eye-brows are drawn towards each other, and the skin of the fore-head pulled down and made to wrinkle, as in frowning, by a pair of small muscles, which rise from the root of the nose, and are inserted into the inside of the eye-brows.

The ear is moved by eleven small muscles. The first three are called common, because they move the whole ear. The next five are termed proper, and only move the parts to which they are connected; while the other three are internal, to move the small bones situated within the ear.

The eye-lids are closed by a muscle, which, rising from the inner angle of the orbit or cavity in which the eye is embedded, covers the under eye-lid, then surrounds the outer angle, and passing over the upper eye-lid, descends to be inserted, by a short, round tendon, near to its origin.

The eye is opened by a muscle, which rising from the inner and upper part of the socket, is inserted into the upper eye-lid, to draw it upwards.

The eye-balls are carried through all their mo-

tions by six small slender muscles to each. They arise from the bottom of the socket, and are inserted into the outer coat of each eye-ball at different points. Four of these move the eye upwards or downwards, to the right and to the left; while the two remaining muscles give oblique directions to the eyes, at the same time protruding it; and all acting in quick succession, enable the ball of the eye to describe a complete circle.

The nose is affected by several small muscles of the face, but only one muscle on each side is proper to it. This muscle straightens the nostrils, and corrugates the skin of the nose.

The mouth and lips are moved by nine pair of muscles, which arising from the contiguous bones of the face, are inserted into the lips and angles of the mouth: and from the termination of these muscles a tenth is formed, which surrounds the mouth like a sphincter, and closes it, by drawing the lips together. It is from the actions of these muscles on the mouth, particularly at its corners, that the emotions of the mind are expressed, and the predominance of particular feelings in characters is indelibly stamped: unless in those individuals whom nature has gifted with an unimpressible dulness of character, or in whom the more delicate lines are filled up by too great fatness. Perhaps it may be worth while to notice the cause of that distortion

of features which is produced by palsy. The muscles on one side then cease to act, while those of the other contracting with their usual force, the mouth is drawn on one side.

The lower-jaw has four pair of muscles for pulling it upwards, as in manducation, viz. two pair which are seen upon the outside of the face, and two pair that are concealed by the angles of the jaw. The first pair arise from the sides of the skull, above the temples, whence they are called temporal muscles; and then descending under the boney bridges of the cheek-bone, are inserted into the lower-jaw near its ends. The second pair arise, at each side, from the under edge of the boney bridge, and descending along the cheek, are inserted into the angle of the lower-jaw. These four muscles act powerfully in pulling the jaw upwards, and when we bite, may be felt swelling out in the flat part of the temple, and upon the back-part of the cheek. The other two pair of muscles arise from the base of the skull, and are inserted into the lower-jaw internally for enabling this bone to move from side to side, the more effectually to grind the food. The lower-jaw is pulled downwards by muscles, which extend between it and the bone of the tongue, and which also serve to raise the throat upwards.

Muscles of the Neck.

The neck is covered with numerous and complicated muscles: those on the fore-part or throat extend some between the head and upper part of the trunk; others between the lower-jaw and the tongue-bone; more between this bone and the cartilages of the throat; while numerous other small muscles are situated between these cartilages and the trunk; and also about the root of the tongue and the back-part of the mouth.

Their uses are, viz. to bend the head forwards; to open the mouth by pulling the lower-jaw downwards: and to move the parts concerned in deglutition and speaking.

The muscles on the back-part of the neck are rather portions of the great muscles, which cover the back, than distinct bundles of fibres; but, having some of their extremities fixed to the back-part of the skull, and also to the hinder portion of the spine of the neck, are intended to move those parts, drawing them backwards and sideways.

Muscles of the Trunk.

Those are principally the muscles which cover the breast; those which constitute the fore-part and sides of the abdomen; and the great muscles that are spread over the back.

The muscles of the back are numerous and large: they arise from the whole length of the spine or back-bone, having their originating fibres firmly fixed to the numerous processes or handles of that bone: from the upper and posterior edge of the pelvis: and also, some portions from the back-part of the skull; and from these different organs, they spread over and cover the back of the trunk, and run to be inserted, some into the base of the arm, others into the spine at a distance from their origin, and the remainder into the ribs and back-part of the skull. They consequently not only cover and protect the whole back-part of the body, but also serve to pull the head backwards, move the whole arm, assist respiration by acting on the ribs, and to give us an erect posture by extending the spine. These are the muscles which suffer in the barbarous practice of whipping; and instances have occurred, where, from the too great weight of the whip, or the excessive number of lashes inflicted, the structure of these muscles has been so cruelly torn and destroyed, as to put it out of the power of nature to restore it; mortification has followed, and the unfortunate sufferer expired a victim to inhumanity or ignorance.

The cavity of the abdomen is completed at its fore-part and sides by a few broad and thin muscles,

which extend from one bone to the other, having their ends firmly fixed to the edges of these bones; and passing over each other, to constitute walls for covering in and containing the bowels. These muscles also assist respiration by helping to expel the air from the lungs: and they contribute to the movement of the body, by bending it forward as in bowing, and by raising the pelvis.

The breast is covered by a few broad and strong muscles, which arise from the whole length of the breast-bone, and form the fore-part of the ribs, and running from each other over the chest, are inserted into the shoulder for moving the limb forward.

The ribs are raised, and the cavity of the chest enlarged, during inspiration, by eleven double rows of small muscles on each side. They grow out from the lower edge of one rib, and are inserted into the upper rim of the next.

Muscles within the Body.

The principal one is called the diaphragm; it is a broad thin muscle, occupying partly a horizontal position, when the body is erect; but inclining downwards towards the back, and dividing the trunk of the body into the two great cavities, the thorax and the abdomen. It arises from the lower end of the breast-bone; from the cartilages

of the seventh, and of all the inferior ribs on both sides; and from the second, third, and fourth lumbar vertebræ; and from these origins its fibres run, like radii from the circumference to the centre of a circle, to be inserted into a broad flat tendon, which is situated in the middle of this muscle. The diaphragm is the principal agent in respiration, as shall be more fully described under that head.

The other muscles within the body arise from the sides of the lower end of the back-bone, and from the inner surface of the pelvis, and passing down to be inserted into the thigh-bone, a little below its head, they help to turn the toes outwards, and to bend the thigh; or when the limb is fixed, they assist in bending the body.

Muscles of the superior Extremities.

These, anatomists divide into the muscles that are situated on the shoulder-blade, on the arm, on the fore-arm, and on the hand.

The muscles situated on the shoulder-blade are called muscles of the arm, because, though they arise from the former bone, which serves to them as a base, yet they are inserted into the bone of the arm, to effect its movements: the same observation holds with respect to the other divisions of these muscles.

The arm then is moved by seven muscles which arise from the shoulder-blade, and passing over the joint are inserted into the arm-bone at its upper and middle parts. These, together with the muscles coming from the back and breast, which are already described, complete the motions of this part of the limb.

The fore arm is moved in flexion and extension by four muscles, which arise from the upper part of the arm-bone; run down its whole length, and constitute its fulness and figure; they then pass over the elbow joint to be inserted into the upper ends of the two bones of the fore-arm.

The hand is moved at the wrist by six muscles; three of these arise from the upper part of the fore-arm, and descending along its whole length, are continued over the wrist, and are inserted into the hand close to this joint; they bend the hand, and are consequently called its flexors. The three extensors, so called because they extend the hand, and bring it backwards, arise from the lower end of the arm-bone, and passing down the fore arm also, run to be inserted into the back of the hand just beyond the wrist: all these muscles, before they reach to the wrist, become slender tendons, which is the cause of the tapering of the fore arm from about its middle to the hand.

Besides flexion and extension, the hand has a

circular kind of motion, called pronation and supination: the former takes place when we turn the palm down, as upon a table; the latter when we turn the palm upwards; and both motions are produced by four short muscles which extend obliquely across from one bone of the fore-arm to the other, and roll the radius upon the ulna, carrying the wrist round in circles.

The fingers are principally moved by two flexors and one extensor. The former muscles arise from the upper part of the fore-arm near the bend, and running down towards the wrist, send off four round tendons each; which passing over the palm of the hand, are inserted, the one set of tendons into the upper part of the second bone, and the other into the last bone of each of the four fingers: the latter set of tendons pass through slits in the former, which help to bind them down, when the fingers are bent. The extensor muscle arises above the elbow, passes down the fore-arm, and also splits into four round tendons, which can be plainly felt on the back of the hand, and are inserted into all the bones of the four fingers for extending them.

The other movements of the fingers, and those of the thumb, are performed by muscles, chiefly situated upon the hand; and which, together with those we have described, compleat the motions of these parts.

Muscles of the inferior Extremities.

The great muscles which move the thigh all arise from the pelvis, or the lower part of the trunk, covering, and also giving plumpness and shape to the external surface of these parts, they descend over the hip-joint, to be inserted into the thigh-bone below its articulating head: by the action of these powerful muscles, the thigh is carried through all its motions.

The leg is moved by eleven muscles, which arise partly from the pelvis, and partly from the upper end of the thigh-bone: they descend along this bone, giving fulness and shape to the thigh, and passing over the knee-joint, are inserted into the bones of the leg: the extensors into the upper edge of the knee-pan, for extending the leg, and the flexors into the posterior sides of the long bones of the leg, a little below their heads: the tendons of these muscles form the inner and outer hamstrings. They bend the leg.

The foot is moved by three extensors, and by four flexors. The extensors arise, the two first by double heads from the lower end of the thigh-bone, near the bend of the knee: these heads soon after unite into the great fleshy bellies, which, swelling out, form the calf of the leg; but decreasing where the leg begins to grow small, they

each give off a broad thin tendon, which also uniting, form the tendon of achilles, to be inserted into the extremity of the heel. Those powerful muscles extend the foot by bringing it backwards, and are principally engaged in running, walking, leaping, &c. The third extensor of the foot arises also from the lower-end of the thigh bone, and descending by a long, slender tendon, is inserted into the heel, to assist the former: but this muscle is sometimes not to be found in the human subject.

The four flexors arise, the two first from the upper part of the tibia, or principal bone of the leg, and continuing fleshy about half way down that limb, send off two round tendons, which pass under the inner ankle, and are inserted into the bones of the foot. The other two flexors of the foot arise from the superior part of the fibula or smaller bone of the leg, and sending off two round tendons, which pass under the outer ankle also, are inserted into the bones of the foot. These assist the former in bending the foot by drawing it upwards.

The toes have two extensors and three flexors. The first extensor arises from the upper part of the leg, and descending to the ankle, splits into four round tendons, which run forward upon the upper part of the foot, where they can be plainly

felt; and are inserted into the four small toes to extend them: the other extensor arises from the heel, and running forward upon the foot, also splits into four tendons, to be inserted into the toes likewise, and to assist in extending them.

The flexors of the toes arise, the first from the under and back part of the heel, and running forward along the sole of the foot, sends off four tendons to be inserted into the second row of bones of the four smaller toes. The second flexor arises from the back part of the tibia below its head, and descending the leg, passes at the inner ankle to run along the sole of the foot, on the middle of which it splits into four slender tendons, which perforate the former, in the manner of those which bend the fingers; and extending beyond them are inserted into the extremities of the last joint of the four small toes. The third flexor assists the two former in bending the toes, and also draws them inwards. Besides these there are other small muscles which are situated upon the foot, and which with those coming from the leg to be inserted into the great toe, compleat the movements of these parts.

Thus we see that the muscles or flesh cover and spread over the whole frame of bones; connecting and securing its different divisions and parts; and not only producing all its movements,

but also giving to it fulness, shape, and beauty. We shall now speak of the motionary powers of those muscles.

OF MUSCULAR MOTION.

Muscular motions are of three kinds; namely, voluntary, involuntary, and mixed. The voluntary motions of muscles are such as proceed from an immediate exertion of the active powers of the will: thus the mind directs the arm to be raised or depressed, the knee to be bent, the tongue to move, &c. The involuntary motions of muscles are those which are performed by organs, seemingly of their own accord (but really by their proper stimuli,) without any attention of the mind or consciousness of its active power; as the contraction and dilatation of the heart, arteries, veins, absorbents, stomach, &c. The mixed motions are those which are in fact under the controul of the will, but which ordinarily act without our being conscious that they do so; as in the muscles of respiration, the intercostals, the abdominal muscles, and the diaphragm.

Motion, as we before observed, is produced by the muscle contracting both its ends towards the centre, when one end being fixed, the other is

drawn towards the centre of motion, and with it the bone or any other part to which it is affixed; and thus, by the co-operation of several muscles, not only a limb, but even the whole body is put into action. This is the case with all the muscles of voluntary motion; their fibres contract on the application of the nervous influence, and the whole muscle shortens itself: and on the same principle the other muscles perform involuntary motion. The heart, for instance, contracts from the stimulating properties of the blood, the arteries do the same, as do the absorbent vessels, by a similar action of their contents, and all those organs and parts which have the power of acting independent of the mind.

We may define all motion in animals then to be the contraction of the muscular fibre from the presence of some stimulating influence. But whence the muscular fibre derives this contractile power, and what is its nature, remains still a phenomenon that baffles enquiry.

Some have supposed it in a degree to depend on colour: but, in fowls, in amphibious animals, in fishes, in worms, and insects, through all the gradations of animals, of different classes, or different sizes, the colours of the muscular fibres change. In fishes, and in insects, it is generally white: even in the human body it is not essentially red:

the fibres of the iris, the muscular coats of the arteries, the muscles of the stomach, and of the intestines, are colourless, and the blood which makes this fibre red in the other parts of the body, may be washed away. Hence we cannot believe that colour is essential to the contractility of a muscle, for this property exists as completely in the muscles of the smallest insect which are colourless, as in those of man that are red.

Others have studied the form of the ultimate muscular fibre with a view to discover the source of its moving power; but this investigation afforded no better light than did that of its size: more again would derive it from the oxygen or vital portion of the air which is absorbed by the blood in the lungs when we breathe: while there are other philosophers who assert that the contractility of the muscular fibre is an original endowment derived from the Creator, imparted in a way we do not know, and so attached to the structure of this fibre, that when its organization is destroyed, this contractile power is lost.

We will here, therefore, resign the search after the mechanical or physical cause of the contractility of the muscular fibre, and seek only to learn the properties of this power, and the excitements by which it is called into action; to this end

it is necessary to define it, distinguishing it from those feelings or motions which result from the nerves. Irritability (or the contractile force of the muscular fibre,) is that power which belongs to muscles of shortening themselves when in any way irritated, and is the source of motion and animal life. The nervous power is that property by which, when a nerve is irritated by pressure or by puncture, the animal feels pain, and the muscles supplied by that nerve are brought into motion; although no contraction or motion are produced in the nerve itself. This power is the cause of voluntary motion, relates chiefly to the enjoyments and consciousness of life: for life and motion exist even in plants, and in many creatures, which not having nerves, have neither consciousness nor enjoyment, and in which the place of feeling is supplied by a less perfect instinct, by irritability, or some analogous inherent power.

When a muscle has shortened itself from the action of a stimulus, and is become swelled and rigid, after a few instants an opposite state follows, which indeed is the one natural to it, namely, a state of relaxation, and that although the stimulating cause continues to act. In this, as well as in many other circumstances, the muscular power differs from elasticity. An elastic body yields to

a mechanical force which stretches it, but instantly rebounds to its former condition when the cause is removed.

When a muscle is relaxed after its contraction, it requires to be replaced into what has been called its middle state between relaxation and contraction before it can again act. The muscle is still shortened, but it will now yield to any mechanical force, by which it may be again lengthened to prepare it for a new contraction.

This replacement of muscles is variously effected, generally other muscles are put on the stretch by the previous contraction, and are thus stimulated to act; such are called antagonists to those first in action.

The hollow muscles, as the heart, intestines, &c. are mechanically distended by their contents, and by this means are alternately dilated and contracted.

Muscles are replaced also by the elasticity of the cellular membrane which enters copiously into the structure of all; and they are frequently attached to very elastsic bodies, which by their rebound act powerfully as antagonists to them.

How far the irritability of muscles is connected with the nervous influence, and depends upon it as a cause, has been long and strenuously disputed.

Some have supposed that in all cases muscles

are made to contract through the medium of the nerves only: while others have contended that frequently contraction takes place from the direct action of the stimulus on the muscular fibre without this intervention of nerves.

Were it possible to separate the nervous fibrils from the muscular parts with which they are intermingled, the controversy might be determined. This, however, is not feasible, and therefore it is impossible to say, but that in all experiments on this subject, the muscles are acted upon through the medium of very minute nerves. In opposition to this we may observe, that the degree of irritability in muscles is not uniformly in proportion to the supply of nerves, for the heart, which has this power in the greatest perfection, has but few, and those very small nerves, distributed through its substance. On the contrary, nervous matter is always found to be sent to organs in exact proportion to their sensibility. Irritability is so far independant of nerves, and so little connected with feeling, that upon stimulating any muscle by touching it with caustic, or irritating it with a sharp point, or driving the electric spark through it, the muscle instantly contracts: although the nerve be cut so as to separate the muscle entirely from all connection with the system; although the muscle itself be separated from the body; although the creature

upon which it is performed, may have lost all sense of feeling, and have been long, to all appearance, dead. Thus a muscle cut from the limb, trembles and palpitates long after: the heart separated from the body contracts when irritated: the bowels when torn from the animal, continue their peristalic motion, so as to roll upon the table, ceasing to answer to stimuli only when they themselves are dead. It is by this irritable principle that a cut muscle contracts and leaves a gap; that a cut artery shrinks and retires into the flesh. Even when the body is dead to all appearance, and the nervous influence has ceased to act; this contractile power remains; so that if it be placed in certain attitudes, before it is cold, its muscles will contract, and it will be stiffened in that posture till the organization yields, and begins to be dissolved. Hence we perceive a striking distinction between the irritability of muscles, and the sensibility of nerves; for the irritability of muscles survives the animal, as when it is active after death; and it continues when the connection of a part with the rest of the system no longer exists, as when animals very tenacious of life are cut into pieces: whereas sensibility, the property of the nerves, gives the various modifications of sense, as vision, hearing, and the rest; produces also the general feeling of pleasure or pain; and thus the

eye sees, and the skin feels; but their appointed stimuli produce no motions in these parts; they are sensible but not irritable. The heart, the intestines, and all the muscles of voluntary motion, answer to stimuli with a quick and forcible contraction; and yet they hardly feel the stimuli by which these contractions are produced, or at least they do not convey that feeling to the brain. There is no consciousness of present stimulus in those parts which are called into action by the impulse of the nerves, and at the command of the will: so that muscular parts have all the irritability of the system with but little feeling; while nerves have all the sensibility of the system, but no irritability.

The nervous influence is a stimulus to the voluntary muscles, as blood is to the heart and arteries; food to the stomach; or bile to the intestines. It loses its influence over the system sooner than the irritable principle in the fibre fails: for the irritable state of the muscle continues long after the voluntary motion, or power of excitement from the nerves, is gone. If, while in perfect health, we are killed by a sudden blow, the irritable power of the muscles survives the nervous system many hours. It is this remainder of the contractile power which fixes the dead body in whatever posture it is placed, and preserves fresh-

ness in the animal which seemed dead, but which is really dying still: for the moment this lingering portion of life is gone, the body dissolves and falls down; and so we judge of freshness by the rigidity of the flesh, and foresee approaching putrefaction by its becoming soft. There is no speedy putrefaction in creatures suddenly killed: in these the body continues fresh and susceptible of stimuli long after death: but if their contractile principle, this irritable nature of the muscular fibre, be exhausted before death, or in the moment of death, then does the body fall quickly into the condition of dead matter, running through those changes which are the only true marks of death. The fish which is allowed to struggle till it be dead, and is not instantly killed, as in crimping: the ox overdriven before it be brought to the slaughter-house: the animal killed by lightning, which suddenly destroys all the powers of life; in these the contractile power is effectually exhausted; no mark of irritability remains; putrefaction comes quickly on: and so in those who die of the plague, of poison, of some fevers, or of any sudden and violent disease, which at once extinguishes life, in the common sense, and robs the system of that remnant of life which the physiologist could produce to view; in all these cases the body becomes putrid in a few hours. If a body becomes putrid so early in warm

climates, it is not merely because putrefaction is favoured by heat; but it is because heat extracts the vital power, and often a part of the body has lost its organized power, and is almost putrid, before the whole be dead. We find that we often err in this, that when a body has lost all feeling and motion, we pronounce it dead; the nerves, indeed, have ceased to act and perform their office; all feeling and consciousness is gone; but the mere animal power survives the nerves, and through it the whole system may be recalled into perfect life; as after suffocation, or drowning, we can by operating upon these poor remains of life, restore the circulation, reanimate the nervous system, and recover that life with seemed to have left the body.

The powers of the nervous system ought, however, to be justly estimated: the perfect animal feels and moves by means of the nerves, which at the same time convey the determinations of the will to the voluntary muscles, and unite every part into a perfect whole; but the muscles themselves are actuated by laws of their own: the heart of the chick begins to move before we dare presume that there is any organ for distributing this nervous power. The punctum saliens is the heart of the chick; it is seen beating while the body of the chick is but a rude, unformed, aud gelatinous

mass; daily the active centre increases in strength and power; and it has a delicate feeling of stimuli, so that it quickly reacts, "flying out into angry and perturbed motions," when they are applied to it. Its motions are excited by increased heat and languish when cold, till at last it dies; then it ceases to act, but still heat restores it to life: and again, when we cut out the heart of a grown animal, so as to separate it from the nervous influence, it will for some time act on the application of stimuli, then appearing to have its power exhausted, it will lie dead for some time, till recovering that power, it will again act.

Sensibility therefore depends upon the nerves; but motion upon the muscles: both are equally admirable and inscrutable; the one conduces to all the enjoyments, and all the sufferings of life; and to the intellectual faculties of man; the other is the chief support of animal life, and the source of all the bodily powers. And here we cannot help awfully contemplating this living power: the genius of man has invented pulleys and levers to accelerate motion: it has enabled him even to anticipate all the mechanical helps which he has found in the mechanism of the human body. But, compared to the lowest creature, animated with the living principle, the proudest works of his hands

are but as dead matter. In the most perfect machines no new power is acquired; if there is any acquisition of force, there is a proportionate loss of time; while in muscular contraction, which is the immediate source of power in animals, there is a real increase of power without any loss of time.

OF THE

BRAIN AND NERVES.

We now come to those organs which endow the human body with feeling; cause all the voluntary motions; and afford a fit residence for the soul: we shall first describe them anatomically, and afterwards speak of their nature and properties.

The brain is a soft pulpy mass of a whitish colour on the inside, but greyish exteriorily. It occupies all that cavity which is formed by the bones of the skull; and is surrounded by two membranes: the first or outermost is called the dura mater; it lines the inside of the skull, and prevents its eminences from giving injury to the delicate structure of the brain: this membrane also serves another useful purpose; it helps to prevent concussions of this organ: for sending off large folds, which enter between the divisions of the brain, it separates the whole mass into portions, which by its partitions it supports and protects from pressure, in the different motions and positions of the head. Three of those partitions are considerable: the first commences at the inside of the fore-head, and running along the roof of the skull, descends to about the centre of the back-part of the head: it divides

the upper part of the brain into two great portions, called hemispheres: the second partition runs at nearly right angles with the first or horizontally, whose termination it receives at its middle; but, extending itself towards each ear, it divides the brain into the upper and under parts, forming a kind of floor for sustaining the former: the third fold runs down from the middle of the second, opposite to where the first ends, and separates the posterior part of the brain also into two divisions. This membrane is strong and of a tendinous nature; like all the other membranes of the body, which are only intended to perform subservient offices for the living parts, it is insensible; being like them composed of cellular membrane: and it may be cut, rasped, or torn, without giving pain: it adheres closely to the inside of the skull, by a great number of filaments, and small vessels, which enter the bones every where, and communicate with the membrane covering the skull.

The second membrane of the brain, called pia mater, is a soft, thin, transparent substance, and full of vessels: it is connected to the former only by the veins which pass between them, and lies in immediate contact with the surface of the brain, not only covering this delicate organ on the outside, but also insinuating itself into all its windings and fissures for the conveyance of vessels, and con-

sequently, nourishment; to supply the wastings of this active intellectual machine. Between these two membranes there is spread a third, which is extremely delicate, resembling a cob-web; but does not dip into the convolutions of the brain.

From the folds of the outer membrane of the brain dipping deeply into its substance, anatomists pursue this division in their description; and hence, although all the parts of the brain unite at the centre of its base, yet they describe it as consisting of three great portions.

The first, called cerebrum, is the largest of the three divisions; it occupies all that space above the horizontal floor of the dura mater, and is separated into two great parts, called, as we before observed, hemispheres: each hemisphere is again divided into three parts called lobes, and has several winding furrows on its surface. The substance of the cerebrum is greyish on the outside, but is white and firmer in texture within.

The cerebellum, or second division of the brain, lies under the former floor at the under and back part of the skull, and is also divided into two portions by the third or descending fold of the dura mater: it consists like the first division of a greyish and white substance; and has each portion or half, again divided into three bodies, but wants the furrows on its surface.

The third division is called the medulla oblangata: it lies at the basis of the skull, and is a continuation or union of the white substances of the other two divisions; being like these of a white colour, and its consistence more firm than that of the greyish portion of the brain.

The spinal marrow, as it is called, is a continuation of this third division of the brain; it passes out of the head by the great opening of the skull, and running down the canal of the back-bone, where it is safely lodged, gives off nerves, till it reaches the pelvis, where, as was before said, when describing those parts, it splits into numerous thread-like nerves, resembling a horse's tail: the spinal marrow, like the brain, consists of a whitish and a greyish substance, and is covered and protected by a continuation of the membranes, belonging to that organ.

The nerves arise from the brain and spinal marrow: they come out in pairs, and are distributed over the whole body: forty pairs are counted in all: of those, nine pair arise from the base of the brain within the skull; a tenth from the brain, as it passes through the great hole of the skull into the spine; and the remaining thirty pair from the spinal marrow. Those arising from the brain pass through holes in the base of the skull, and are distributed chiefly to the organs situated in the

head, and to those contained in the chest and belly: while the nerves which arise from the spinal marrow go, partly among the internal organs of the trunk, to be distributed principally to the exterior parts of the body, and to the extremities or limbs. All the nerves arise, first by medullary fibres, which afterwards meet, and form soft, white, pulpy chords: these chords run out in pairs from their origin; but soon afterwards separate, to go to different parts, and spread themselves over the whole body, by splitting into innumerable ramifications.

What is the structure of the brain and nerves, has been a matter of investigation in all ages, but without success: their substance appears to be a mere soft, pulpy, mass, and this simplicity of texture baffles the eye and researches of the anatomist. We see their form, and can trace different appearances which it would be here needless to describe; but we are scarcely able to discover any system of organization. The celebrated Fontana fancied he had discovered that nerves consisted of minute tubes filled with a sort of gelly, and that the tubes were connected by a cellular tissue. These ideas were founded, however, on microscopical observations, which have often led anatomists into errors.

The nature of their powers, their mode of action, have also engaged the inquiry of numerous

philosophers, and with no better success than the former. The same subtlety hides from the knowledge of man both their structure and agency; we read the operation of the mind in the universal history of human affairs, and measure its powers in the extent of genius and science; but though we can thus view the astonishing properties of the brain in their results, and even analyze some of the laws which regulate them; still are we at a loss to explain how those results are produced, or by what means a single act of the mind flows out of the matter of the brain.

Resigning, therefore, all enquiry after that link which connects the mind with the matter of the brain, and which, perhaps, is reserved for future discoveries to throw some light upon; we shall now speak of those known properties of the brain and nerves, which experiment enables us to deduce as facts.

First, then, the brain and nerves are sensible, constituting the organs of feeling and sensation in the animal machine.

That the brain and nerves are sensible is proved by the following facts.

Upon touching the brain with a knife or any other instrument, or upon applying any caustic body, the animal will be seized with violent convulsions, its body will be contorted on one side or

the other in the form of a bow: and the most violent anguish will be expressed by its screams.

If a probe be thrust into the spinal marrow, (which we have seen to be a continuation of the substance of the brain) all the muscles of the limbs will be violently convulsed, and those of the back will be so much affected, as to bend the animal backwards.

And by touching, irritating, or tying a nerve, the muscles to which its branches are distributed, will be violently convulsed, and the animal thrown into the most acute pain and disquietude.

Secondly, all the other parts of the body derive their power of feeling and sensation from the brain, the spinal marrow, and the nerves. Being in themselves wholly insensible, and made capable of feeling only in proportion as they have the nervous branches distributed to them.

That this is the case, is proved as follows.

If you tie a nerve going to any part, that part becomes immediately paralytic, and insensible below the ligature; but will recover its powers on freeing the nerve.

And it is also proved by the degrees of sensibility of the different parts of the body, bearing proportion to the quantity of nervous branches, which can be discovered to belong to the part. Thus, while in some places, we find a conflux of nerves

forming the most delicate and perfect sense, and endowing that part with the fullest life; there are other parts of the body, as the bones, cartilages, ligaments, and tendons, which while they are almost destitute of nerves, are so insensible, as to be cut, torn, or even totally destroyed without exciting pain.

Thirdly, the excitement to all voluntary motion, or to those actions which are produced by the will, flows from the brain or spinal marrow, through the medium of the nerves, to those parts of the body which we wish to move.

That the immediate cause of all voluntary motion depends upon the brain and spinal marrow, is seen by the loss of this motion taking place on the injury of these organs.

If, for instance, the brain be compressed either from an extravasation of blood, water, or other mechanical causes, the whole body will become paralyzed, and the power of motion suspended; but, on removing the compressing cause, this paralysis will cease, and the whole frame will recover its sense and motion.

Compression of the spinal marrow will also cause loss of motion and sense, but only in those parts which receive their nerves from it, as the external flesh of the trunk of the body, and muscles of the limbs.

And, if a nerve, which conveys the immediate cause of motion from the brain, or spinal marrow, to the parts to be moved, be either cut or tied, or otherwise compressed, the part to which this nerve is distributed, will immediately become senseless, and lose its power of motion; thus injuries of particular nerves produce palsies of the parts to which those nerves are sent; as loss of voice, hearing, and speech; but on removing the cause, the disabled parts will recover their functions.

Fourthly, the nerves are the organs, and the brain the receptacle of all our sensations, the source of all our ideas.

That sensation arises from an impression made on a nerve and conveyed by it to the brain to be followed by some action or change in that organ, and which change is so far permanent as to produce ideas, is proved by the following facts.

If a nerve be in any way irritated, a sharp sense of pain is immediately produced; the mind in the brain, becomes instantly informed of the suffering, and efforts are made to relieve the part: but if that nerve be compressed above the seat of its irritation, so as to cut off the channel of communication between it and the brain; the mind is then no longer conscious of any irritation that is made below the point of compression; and the affected parts are reduced to a state of insensibility similar

to that of parts which are destitute of nerves, and may be cut or destroyed without exciting pain: but by removing the compression from the nerve, the parts below will recover their sensibility; the irritation will be felt anew; and the sensation of pain again propagated along the nerve to the brain, to inform the mind of the presence of an injury.

Now pain is only the result of an impression made to excess; that is, a set of disagreeable sensations, produced by the too forcible contact of bodies with the organs of our senses: and it is wisely implanted in the human system to guard it against injury; for without it, the delicate structure of our frames would be almost continually liable to destruction from various bodies in nature around us. But as pain is the salutary consequence of excessive, so sensations without pain are the results of a due impression on our sensitive organs, from the objects which are calculated to influence us: and as long as the body remains in health in all its parts, these impressions will continue to cause sensations in the nerves; which, on their part, will forward them to the brain, where ideas of the nature and properties of the impressing objects will be instantly formed for the instruction of the mind. Thus the skin and other parts possessed of what is generally called feeling, will be susceptible of touch, and communicate to the mind

in the brain, the sensations of the hardness or softness, the roughness or smoothness, &c. of such bodies as may be brought in contact with it; while the organs of the other senses, as the eye, ear, nose, and palate, being differently, and more highly organized than the skin; though deriving their sentient powers from the same source as the latter, namely the nerves, yet, by their regular structure, are enabled to receive different kinds of impressions, each according to its properties and conformation; as the eye will be impressed from light, the ear from sound, the nose from smell, and the palate from taste; and by those various impressions, an extensive and varied knowledge will be transmitted to the mind in the brain of the nature of the objects in correspondence around her.

That the brain not only collects, but also preserves the sensations to an indefinite length of time, is seen in the astonishing strength of the memory of some individuals.

That the brain is the seat of ideas any one may convince himself, by shutting his eyes for a moment to exclude the influence of present objects, when he may figure in his mind the exact likeness of some dead or absent friend, of a favourite horse or dog, or of any other familiar object.

Lastly, the brain is the seat of the soul.

This is proved by the constancy and powers of the mind remaining the same, even after the spinal marrow is obstructed, by compression or any other injury: while compression of the substance of the brain itself, instantaneously suspends the mental powers, and continues to do so until that compression is removed.

Thus we see that the brain, spinal marrow, and nerves, alone constitute the sentient or feeling part of the human system, and that all its other parts, being composed of matter, totally insensible in itself, are possessed of the capability of feeling only in proportion as they receive the branches of nerves. Hence, there is a kind of gradation of feeling throughout the whole body, each of its organs and parts being endowed with that degree of sense, but no more, which will be sufficient for the performance of its function in the living machine. The cellular membrane, for instance, whose use it is to connect together, and unite into one whole, all the moving parts of the system, is without feeling, being insensible to stimuli: this also is the case with the coverings of the brain; the coats of the nerves; the sheaths of muscles; of tendons; ligaments; and all the apparatus of joints; together with the substance of the tendons and ligaments themselves; for these parts performing only sub-

servient offices to the living organs, would derange the whole system, by being possessed of a sensibility, which would leave them no longer capable of bearing the friction, straining, shocks, and blows, which they now endure without injury in the different movements of the frame. The feeling of bones is dubious: if they possess any, they certainly do not send the sensation to the brain, but in their diseases, as in wounds of joints, &c. the great pain, which the patient suffers, evidently shews them to be then not insensible. The muscles are all endowed with the sense of feeling, by a distribution of the nervous fibres every where throughout their substance: this is necessary to their office; as agents of voluntary motion, they must be capable of receiving and obeying the commands of the will, and they are so in fact; hence the mind no sooner wills an act, than the command flies along the nerve to the part to be moved, and the action is instantly performed; this dispatch is illustrated in the rapid movements of an opera dancer, every one of which were resolved upon in the mind, before they could have been executed by the feet; and at least as strikingly in the organs of speech, by which 2000 letters can be pronounced in a minute, each requiring a distinct and successive contraction of many muscles. The skin possesses a finer degree of sense than the flesh,

being fuller of nervous branches; and rising in the scale of sensibility, may be said to form the lowest of the organs of the senses. Feeling is the property and use of the skin of the human body, which enjoys it over its whole surface, but more exquisitely in some parts than in others: thus while the greater part of the skin possesses it in a degree sufficient only to guard the body from danger, by warning it of the contact of substances, which being too hot, too cold, too sharp or rough, might be injurious; there are other parts, as the palm of the hands, and sole of the foot, which are endowed with a greater sensibility, so as on a slight friction, to create a tickling kind of pleasure; and in some persons involuntary laughter. But it is most perfect in the points of the fingers, which, from their convexity, are particularly adapted to be the organs of touch, and from the nice discrimination with which our fingers enable us to examine the surfaces, and exterior properties of bodies, this sense has got the denomination of feeling. The tongue, the organ of taste, possesses this sensibility in a higher degree still; for though it judges of the substances which constitute our food, by the same process as that used by the fingers, namely contact; yet the latter with their finest feeling would be inadequate to discover bodies by their flavour. A step higher may be ranked the organ of smell-

ing; the nose is so acute in its sense, as to be impressed by the light and volatile effluvia rising from bodies, and floating in the air, and can consequently distinguish substances at a considerable distance. Higher again stands the sensitive faculty of the ear: this organ is qualified to be acted upon by the mere vibrations of the air, which striking against this delicate part of our mechanism, produces sounds, and affords us information of things occurring at a great distance. But the most perfect of all the senses, and ranking, perhaps, next to the more simple operations of the mind, is that of sight. The eye, the beautiful organ of this power, is a type of its functions; in transparency, delicacy, and brilliancy, it surpasses all the other parts of the body, appearing to lose the grosser characteristics of animal matter, and to approach the nature of the mind, to which it serves as the most useful, rapid, and extensive messenger, for procuring knowledge of the various objects in creation around us.

Such is the varied distribution of sense which we see the brain and nerve bestowing upon the other parts of the frame. We are familiar with its uses; we know the kinds of bodies which are calculated to impress the different organs; and even the manner in which those bodies effect their impressions; and farther, we can define and trace

the limits of the senses themselves. Thus, for instance, we can determine the extent of vision, hearing, &c. but, when we ascend one step higher in our researches, and inquire into the nature of the brain and its operations, our reasoning becomes but conjecture, and the further we advance, the more are we lost in wonder and admiration of this astonishing part of our system.

Even the means which the brain employs for sending her commands, and excitement to voluntary motion, along the nerves, have exhausted the fertile, but fanciful regions of hypothesis, without success. Some have supposed, that an extremely subtile fluid, secreted in the brain, and flowing through the nerves, was the immediate cause of sensation and motion: others, again, to account for its rapidity, have asserted that the fluid must be electric; but both opinions have no absolute proof for their foundation. Certainly the electric fluid may possess a celerity of motion, equal to that with which the will sends her commands to the different parts of the body. Louis the Fifteenth had two thousand men drawn up in line, to be electrified with their hands locked together; when the shock was propagated with such velocity, as to be felt at the most distant extremity of the line at the same instant in which it was received by the first man; but then we cannot conceive

how such a fluid could be confined within the soft, pulpy, substances of the nerves, and prevented from dissipating itself through their surrounding parts, which are conductors of the electric fluid.

The galvanic influence is that which is created by placing the bare muscles of an animal upon a plate of metal, and communicating the nerve of a limb with the plate by means of another metal of a different kind, as with zinc and silver. This is the simplest form of the experiment, but it has been varied, and so improved upon as to accumulate a prodigious power by combining many such pieces. It is by far the most potent exciter of the nervous energy we are yet acquainted with. It produces forcible contractions in every part of the body after death, even when common electricity fails, and long after other agents have ceased to produce the least effects on the muscles. In the living animal it will excite sensations of taste, of sight, and of painful feeling, if applied to the eye, to the tongue, or to the bare skin.

Still, however, it is an error to imagine the metallic influenee is really the nervous power; it is certainly not so, but merely an active stimulus to the nerves, and is probably an electrieal phenomenon, although the mode of its operation be quite unknown. The opinion now most generally received is, that the blood in passing through the

lungs, receives certain properties from the air, which it afterwards gives out in its circulation over the rest of the body; and as one sixth part of the blood of the whole system is constantly circulating in the brain, it is reasonably supposed, that this great quantity, too great for the mere nourishment and renewal of the wasted parts of that organ, is intended for the secretion of those properties which it has imbibed from the atmosphere, and by which the nerves perform their function.

We shall close this article by contemplating, for a moment, the brain in its intellectual operations. It is not the mind of an individual, nor of a nation, however able and enlightened, that can lead us to the extent of the powers evolved by the brain. To estimate the capacity of this wonderful organ, it is necessary to extend our view to the whole system of the human race, and trace their history from the remotest period, along the lapse of ages, to the present time: it is in the numerous systems which man has contrived and executed during this long interval, for the accomplishment of his happiness, that we see him displaying his intellectual powers: all his establishments, political, civil, and military, are merely developements of the mental faculty: by it have been framed all his regulations, social, and moral: every improvement, every degree beyond the mere state of nature

has its origin from this source, it is the foundation of all our present civilization.

By his superior intellect, the philosopher surveys the creation around him, and transfuses into the affairs of men, the wisdom, and beneficence, which he discovers in the system of the universe. The astronomer, by the force of his mind, penetrates the heavens, and, discovering new worlds, peopled, perhaps, with myriads of unknown beings, sublimes the soul, and expands our admiration of the Supreme Being and his works. By the same means the chemist is enabled to analyse the various substances in creation around him, and, tracing nature to her recesses, draws forth valuable instructions for the application of bodies, to our necessities, and our gratifications. While the bulk of mankind, led by the genius and science of others, are directed, nevertheless, in all their proceedings, by the same intellectual faculty, though using it in a more humble degree; but even this extensive view of the collective operations of the brain, only enables us to estimate the ability of that organ to the present time; the powers it may unfold under new circumstances and combinations in life, remain for futurity to ascertain.

OF THE

SENSES AND THEIR ORGANS.

Next in order to the brain and nerves, come the organs of the senses: as was observed before, the mind in the brain being intended to hold a correspondence with all the material beings around her, requires to be furnished with organs which can receive the different kinds of impressions that may be made; hence she has the eye for seeing, the ear for hearing, the nose for smelling, the tongue for tasting, and the skin for feeling. By the various impressions which these parts receive, and transmit along their nerves to the brain, the mind becomes acquainted with the creation which she inhabits. We shall commence with the description of the eye.

Of Vision.

The eye is lodged, for its safety, in a socket formed partly by the bones of the skull, and by those of the face: and for the greater security of this delicate organ, it is defended on the outside by the eye-lids, which serve as an occasional covering against external bodies; while a fine, limpid fluid, secreted from a small gland, which is situated near the outer angle of the eye-lids, is constantly spread

over the surface of the eye, to keep it moist and transparent; and to wash away those particles, which, floating in the air, might have attached themselves to this surface, and produced injury. This fluid, called the tears, afterwards passes off by two small openings at the opposite or inner angle of the eye; and thence descends by means of a canal, into the nose. The eye-lashes grow out from the edges of the lids, and serve not only to protect the eye from insects and minute bodies; but also to moderate the action of the rays of light in their passage to the eye: and these rows of hair, together with the eye-brows, are likewise intended to ornament the countenance.

Each eye-ball is partly transparent and partly opake: the former portion transmits the rays of light to the nerve, which is spread at the back part of the eye; while the latter serves as a covering to this organ, and is intended also to confine the waters of the eye, and limit the passage of the rays of light. The opake part consists; first, of the white outside coat which covers all the back part of the globe of the eye, and running forward joins its anterior edge to that of the transparent coat, called cornea, and which is placed at the fore part of the eye. These two coats form the outside covering or case for containing the other parts of the eye, and from their difference of structure

and use, are not inaptly compared to the outside case of a watch, the transparent coat answering to the glass, and the opake one to the case into which it is fixed. It is the external part of this opake coat which forms the white of the eye. Immediately upon the inside surface of this coat is spread another, the choroid, which is also opake, but being of a more delicate structure than the former, serves as a soft, easy bed for the optic nerve to expand upon. This coat also runs forward towards the circular edge of the transparent part of the eye, and here its edges appear to be thrown off, to form a kind of curtain with an opening in the middle, the pupil, for the passage of the rays of light. This curtain is called the iris, and together with the choroid coat, of which it seems to be a continuation, owes its dark colour to a black mucus, not dissimilar to that which is found under the scarf-skin of the negroe; and which is spread more or less on the surfaces of these parts of the eye for the purposes of accurate and distinct vision by absorbing the superfluous rays. The optic nerve descending directly from the brain, passes through an opening into the orbit, to enter the posterior side of the eye in a trunk, about the size of a goosequill. Having penetrated the coats which we have described, it then expands into a very delicate membrane,

lining the ball of the eye, for receiving the rays of light, which the transparent parts of the eye transmit to it. We will now describe those parts.

The lucid or transparent portion of the eye constitutes the principal share of this organ, and is composed of extremely fine and pellucid membranes, and humors of a greater or less density: the first, and principal membrane is that which we have compared to the glass of a watch, serving at the fore part of the eye as a covering to the parts within, and calculated also to transmit the rays of light. Immediately before the retina or expansion of the optic nerve, and occupying the posterior part of the eye, lies the vitreous humour, so called from its resemblance to fused glass. This humour consists of a fine clear liquid, contained within the very minute cells of a delicate membrane: and is a little hollowed at its fore-part for lodging another humour, the crystalline, which is of a firmer texture, and of a lenticular shape. All the remaining space of the eye is filled with what is named the aqueous humour, because it is a thin, clear water, not contained within any cells, but lying immediately in contact with the coats and other parts of the eye: this fluid supports the convexity of the eye before, and will escape on puncturing the transparent cornea, which lies on its outside.

Vision is effected by the eye through the medium

of light, for the rays passing directly from the objects which we behold, to this organ, penetrate its transparent parts, till they fall upon and impress the retina or expanded nerve at the bottom of the eye: now the scope of vision being great, while the retina or seat of impression is but limited in size, it follows that objects can be painted only in miniature on this part, and that for this purpose its apparatus was necessary, to converge the rays of light, so that they conveyed a diminished figure of the object to the nerve of the eye: this is really and principally the use of the transparent humours of this organ. They refract and converge the rays of light, in the manner of a camera obscura; which represents an artificial eye; so that a distinct image of the object we look at, is formed at the bottom of the eye; and this point of convergence of the rays, is called its focus. As in a camera obscura, so also on the retina, objects are painted in an inverted position: this happens from the necessary decussation or crossing of the rays in their passage to the nerve, and may be seen by cutting away the back part of the opake coat of the eye, and placing a piece of paper to receive the object: habit alone enables us to judge of the true situation, and likewise of the distance and magnitude of objects. To a young man who was born blind, and who was couched by Mr.

Cheseldon, every object (as he expressed himself) seemed to touch his eyes as what he felt did his skin; and he thought no objects so agreeable to him as those which were smooth and regular, although for some time he could form no judgment of their shape, or guess what it was in any of them that was pleasing.

In order to paint objects distinctly on the retina, the cornea or transparent fore part of the eye is required to have such a degree of convexity, that the rays of light may be collected at a certain point, so as to terminate exactly on the nerve: if the cornea be too prominent, the rays, by converging too soon, will be united before they reach the retina, as is the case with near-sighted people; and, on the contrary, if it be not sufficiently convex, the rays will not be perfectly united when they reach the back part of the eye, which happens to long-sighted persons, and which is found constantly to take place as we approach to old age, when the eye gradually flattens. These defects are to be supplied by means of glasses. He who has too prominent an eye, will find his vision improved by means of a concave glass, which by scattering the rays, counteracts its too great converging powers; and, upon the same principles, a convex glass will be found useful to a person whose eye is naturally too flat.

Of Hearing.

Every one knows the figure of the external ear, which collects the modulated air by its irregular surface, and curiously winding channel, for the propagation of sound in the internal parts: we will therefore pass to the description of the latter.

The internal ear, the immediate organ of hearing, is seated within the temporal bone of the skull, and consists of certain cavities, labyrinths, and passages hollowed out of its substance; together with their fine lining membranes, some very minute bones, and the auditory nerve. The first passage is a canal of considerable length, which leads from the external to the internal ear; it is lined with a fine membrane, and is furnished with several small hairs for guarding the parts within from the entrance of insects. The inner extremity of this canal is closed by a thin transparent membrane, set in a bony circle like a drum-head: under this membrane runs a branch of a nerve; and immediately beyond it lies a small cavity, called the drum of the ear; this cavity contains a chain formed by four small bones, which are furnished with muscles, and cartilages, and regular articulations: it is of a hemispherical shape, and has four openings from it: the first is a small canal communicating with the back part of the

mouth: the other three are holes which open into different recesses of the ear, and are covered with a very fine membrane. One of these openings directly leads through a bony partition, into what is called the labyrinth of the ear: this part of the organ of hearing consists first of an irregular cavity much smaller than the drum of the ear; next of three semicircular canals, each of about a line in diameter, and which open by both their extremities into this cavity; and lastly of a spiral canal not unlike the shell of a snail, making two turns and a half from the basis to its apex, and opening also into the former cavity: all these parts of the labyrinth are lined with a very fine membrane, and are filled with a watery fluid, which transmits to the nervous pulp in contact with it, the vibrations it receives from the membrane separating the labyrinth from the drum of the ear.

From the situation, the variety, and the minuteness of the parts composing the ear, we are not permitted to know exactly the mode of action of this intricate but admirable organ: it is certain however, that the auditory nerve which is distributed over the whole of the labyrinth, is the seat of the sense of hearing; and that a certain modulation of the air, collected by the funnel-like shape of the external ear, and conveyed through

the first canal which we have described to the membrane, and thence communicating its vibrations to the nerve, is the cause of hearing. That sound is propagated to the ear by means of the air, is proved by ringing a bell under the receiver of an air-pump: the sound it affords being found to diminish gradually as the air becomes exhausted, till at length it ceases to be heard at all. We shall now describe the manner in which it is supposed, that hearing is effected.

Sound being created by the stroke of some body against another, causes an undulating action in the surrounding air, not unlike to the circles which take place on throwing a stone into smooth water: and these waves of the air, travelling at the rate of about thirteen miles in a minute, beat against the external ear: here they are collected and conveyed through the canal to the membrane closing the drum of the ear. Against this membrane they strike so as to force it into oscillation, when the vibration is propagated onwards by the small bones in the drum of the ear, till it reaches the labyrinth, where communicating its impulse to the watery fluid contained in its cavities, the auditory nerve at length becomes affected by the tremour of the water, and the sense of sound is produced.

Of Smelling.

The nose, the organ of this sense, forms a prominent feature in the human countenance, and needs no particular description: externally, or that portion which projects beyond the face, the nose is constructed of bones, cartilages, small muscles, and the skin; the internal part of this organ, which is the seat of smelling, has an extensive surface formed by the convolutions of four small bones; two in each nostril. A soft pulpy membrane covers them through all their windings, and upon this the branches of the olfactory nerve are copiously distributed.

Many cavities and recesses, formed in the bones of the skull, communicate with the nose, perhaps to increase the power of the organ: in addition to another purpose for which they were designed, namely, to add to the sonorousness of the voice.

The sense of smelling is effected by the membrane before described. The subtile and invisible effluvia of bodies, consisting of their volatile, oily, and saline particles, being carried with the air in which they float, through the nose in inspiration, strike against the almost naked and soft olfactory nerves which are every where spread throughout this membrane, and are kept moist by a constant secretion of mucus, and produce in them a kind

of feeling, which we call smelling. This sense, besides adding to our sum of pleasurable feelings, seems intended to direct us to a proper choice of aliments, warning us to avoid those which may be putrid or otherwise dangerous; and also for admonishing us to fly from such exhalations and vapours as vitiate the air, and render it injurious to life. When we wish to take in much of the effluvia of any thing, we naturally close the mouth, that all the air we inspire may pass through the nostrils, and at the same time, by means of the muscles of the nose, the nostrils are dilated, and a greater quantity of air is drawn into them. In many quadrupeds who are to find out their food at a considerable distance, or are compelled to select what is proper for them from much that is improper, the sense of smelling is much stronger than in man: and even with him it differs in acuteness, as it has been more or less vitiated by a variety of smells.

Of the Taste.

Another sense which the all-wise creator has given to assist us in the proper choice of food, and also for combining pleasure with the necessity of taking in fresh nourishment, is the sense of taste; this property resides in the nervous extremities or papillæ, which lie upon the extremity and sides of the tongue; and is excited by the contact of those

bodies, whose properties are calculated to act upon these nerves. Thus by making different kinds of impressions, owing to their various qualities some substances being mild, others acrid and pungent, are the different tastes of sour, sweet, austere, &c. produced; but the particular state of these nervous papillæ of the tongue, with respect to their moisture, their figure, and their covering, will produce a considerable difference in the exercise of this sense; hence it varies in different people, and suffers great changes even in the same person, by sickness and by health.

The capability of the tongue to feel a difference of tastes, has been providently implanted, that we might distinguish such food as is most salutary: for in general those which are so are found to be pleasant, and those which are ill-tasted are rarely fit for our nourishment. In this manner nature has invited us to take necessary food, as well by the pain called hunger, as by the pleasure arising from the sense of taste. But brute animals, who have not, like ourselves, the advantage of learning from each other by instruction, have the faculty of distinguishing flavours more accurately, by which they are admonished to abstain cautiously from poisonous or unhealthy food; and therefore it is that herbiverous animals, to which a great diversity of noxious plants is offered amongst

their food, are furnished with long and large papillæ in the tongue; which are not so necessary to man.

Of Touch.

The sense of touch is that faculty by which we distinguish certain properties of bodies by the feel; and in a general acceptation, may, perhaps, not improperly, be said to exist in all the parts of the body possessed of sensibility. But the term is commonly confined to the nervous extremities or papillæ of the skin, and which being more numerous, or covered with thicker or thinner cuticle in some places than in others, give, as we before observed, a grosser or finer degree of feeling to the different parts: these papillæ are capable of being impressed by the exterior properties of bodies, whence the mind is enabled to form ideas of their solidity, moisture, inequality, smoothness, dryness, fluidity, and also of their degree of heat. But the part of the skin which possesses this sense more perfectly for the examination of substances, is that covering the points of the fingers; which from the peculiar disposition of its nervous papillæ, and also the convex shape of the part on which they lie, is admirably calculated for enquiring into the nature of bodies by the feel.

We have now rapidly described the senses and

their organs; in each of the latter we have seen the nerve to be the seat of impression; and the organ itself a kind of apparatus for conveying to the nerve a particular influence from the impressing object. Thus the transparent parts of the eye are calculated to transmit the rays of light to the nerve which is spread behind them: the ear to collect, concentrate, and propagate the vibrations of sound, till they strike against the nerves distributed in the labyrinth; and the nose, tongue, and fingers, are so constructed as that the nerves which are spread upon those parts receive different kinds of impressions by contact, owing partly to the difference of the medium through which the nerves are acted upon; the membrane which covers them, being in some organs of a different structure, and sometimes denser than in others. Hence we see that there is a common seat for impression in all the organs, that the difference of sense is created by the organ itself, whose peculiar construction is calculated to receive only a particular influence from the impressing body. What admirable simplicity! and yet how astonishing are the operations of these beautiful parts of our mechanism.

Of the Face.

Some of the organs which we have described, assist in composing the face; it will be in order, here, to trace its other parts, and then to observe generally of this expressive and striking portion of our frame.

Besides the eyes, nose, and ears, the other parts of the face present separately nothing very particular in their structure or uses. The fore-head covers the greatest part of the frontal-bone of the skull, on the inside of which lies the brain, descending as low as the orbits; and it is ornamented at its lower edge by the eye-brows, which also serve as defences to the eyes: from the fore-head the skin is continued to form the eye-lids, whose uses, together with that of the beautiful row of hairs which grows from each of their edges, we have already explained. The cheeks serve as side-walls to the cavity of the mouth, and also constitute the principal share of the face; in many persons they are tinged with the rosy bloom of health, and are lined on the inside with a membrane full of small glands, for secreting a liquid to moisten the mouth. The lips compleat the cavity of the mouth, and form its aperture; they are moved, as was before observed, by several small muscles, and are covered on their edges with a

beautiful red border, consisting of fine, villous papillæ, closely connected together, and extremely sensible; being defended only by a very thin membrane. While the chin terminates the inferior boundary of the face, and compleats the number of its divisions.

The features of the face viewed collectively present a striking, but beautiful characteristic of the superior nature of man: perhaps in the whole creation there is not another object which breathes so many, such various, and such elevated influences, as does the human countenance. It is the image of the soul, the place where her ideas, motions, &c. are chiefly set to view, and the seat of the principal organs of sense. To the countenance we naturally look in conversation for the full meaning of the words expressed; and by it we are enabled to anticipate the emotions and feelings of others, before they yet reach the tongue. It speaks a language peculiar to itself, anticipating and outstripping all others in rapidity; which is general to all nations, and intelligible to every individual of the whole human race: by this language have our circum-navigators been able to hold converse with, and interchange civilities between themselves and the untutored inhabitants of remote regions. Even the brute animals, whom man has domesticated and made his occasional companions,

are not ignorant of this kind of expression: when the dog wants to know the commands of his master, unable to understand them in the complicated sounds of his speech, he looks intently upon his face, and endeavours to collect from it his wishes and the disposition with which he regards him. Nor does this expression entirely forsake the face of man even in death. All the affections of the mind are more or less portrayed in turn in this limited but expressive field: love, pity, courage, fear, calmness, anger, and every other marked condition of the mind gives a peculiar disposition to either the whole or some features of the face; and when we see them impressed by characters expressive of virtue and wretchedness, of injury and innocence, our feelings are awakened, and the noblest sympathies of our nature called forth in favour of the sufferers.

To the size and proportion of the bones underneath, and which constitute the basis of the face, is the difference of features to be principally attributed; youth, age, sickness, health, and even the stronger affections of the mind, no doubt, have an effect in changing the countenance; but that diversity of feature consisting of the difference of length, breadth, or projection, depends chiefly upon the bony frame that lies below it. Hence arises the Aquiline, the Grecian, and the flat or

African nose; also the high cheeks of the Tartars, and the more regular ones of the people inhabiting the west of Europe; likewise the projection and sharpness, the breadth and flatness of the chin of different persons.

From this difference of features, is that great diversity produced, which varies the countenances not only of nations, but also of individuals; so that no two, perhaps, of the whole family of mankind could be found exactly alike. But, notwithstanding this surprising diversity, we are not to suppose that the individual features composing each face are different from those of all other faces; we are rather led to believe, that, like the letters of the alphabet, features are confined to a limited number of kinds or sorts; but that each is capable of an indefinite number of combinations with other features; and that as from twenty-four letters all the words composing a language are constituted, so are produced, from perhaps a very few kinds of features, by transposition, the astonishing and beautiful variety of faces we see around us.

This supposition is supported by the simplicity of means with which nature is known to delight in for effecting her purposes; and in a great degree by the likeness which often exists between two faces, and which, in some cases, is so perfect, that one shall be mistaken for the other. For

a further knowledge, however, of this beautiful and expressive part of our frame, we refer the reader to the writings of the celebrated Lavater on the human physiognomy.

Of the Complexion.

The colour of the skin has engaged the attention of most naturalists, and by the diversities which it exhibits among different races of people, it once gave rise to opinions, some of which were innocent, but others extremely injurious to the happiness of mankind; as directly asserting, that, in violation of the eternal principles of justice, and the sacred rights of humanity, the people of one colour had a right to seize and enslave those of another. But now the seat of colour being discovered, and some of the circumstances which influence its changes being known, those erroneous opinions are exploded; and instead of seeing grounds for the assault and slavery of our fellow-creature, in the difference of his complexion from ours, the philosopher contemplates the shades of the human countenance, as he does the variety of its features, and beholds alike in both the provident design and work of the supreme architect.

It was not till lately that the true seat of the colour of the skin became known. Prior to this, anatomists supposed that colour depended on the outer or scarf skin; and before the dissection of

the human body, it might have been even imagined that colour entered deeper than the skin, and had influence on the other and more internal parts of the frame. Malpighi, an eminent Italian physician, at length led to the knowledge of its true seat. He was the first who found that the skin of the human body consisted of three parts, separable one from the other; namely, the scarf-skin which is external, the thicker or true skin beneath it, and a coagulated substance which lies between both. On future investigation it was discovered that this coagulated substance was exclusively the seat of colour in the skin, and what caused the various shades of complexion in the different inhabitants of the globe. This discovery has been since fully confirmed by anatomical experiments. If the scarf skin be separated from the coagulated substance underneath, it will be found to be semitransparent; this is invariably the case with the scarf-skin of the blackest negroe, and with that of the purest white. Whence it follows that the outer skin of both being similar in transparency and colour, (and the inner or thicker skin being known not to differ in persons of the most opposite complexions) the intermediate coagulated substance must be the seat of colour; and this substance varying in its tint, and appearing through the transparent scarf-skin, gives them

those different complexions which strike us so forcibly in contemplating the human race.

Whatever causes co-operate in creating these appearances, produce them by acting upon the coagulated substance; which, from the almost incredible manner in which the scarf-skin is perforated, is as accessible as this skin itself. These causes are probably those various qualities of things, which, combined with the influence of the sun, contribute to form what we call climate. For the coagulated substance is found to vary in its colour from the equator to the poles; being, in the highest latitudes of the temperate zone, generally and perpetually fair, but becoming swarthy, olive, tawny, and black, as we descend towards the south.

These different colours are no doubt best adapted to their respective zones; although we are ignorant how they act in fitting us for situations that are so different; and the capability of the human constitution to accommodate itself to every climate, by contracting after a due time the shade proper to it, affords a fine illustration of the benevolence of the deity. This pliancy of nature is favourable to the encrease and extension of mankind, and to the cultivation and settlement of the earth: it tends to unite the most distant nations; to facilitate the acquisition and improvement of

science, which would otherwise be confined to a few objects and to a very limited range: and also, by opening the way to an universal intercourse of men and things, to elevate the various nations of the earth to the feelings of a common nature, and a common interest.

Of Speech.

It has been observed in the introductory view, that the mind being formed for society and intercourse with beings of her own kind, requires to be endowed with powers of expressing and communicating her thoughts by some sensible marks or signs, which shall be both easy to herself, and admit of great variety; and that she is therefore provided with the organs and faculty of speech, by which she can throw out signs with amazing facility, and vary them without end. We shall first examine the organs for producing speech, and afterwards take a view of this superior and distinctive faculty of man.

The organs for effecting speech are the mouth, the windpipe, and the lungs. The first of these is known to every one, as also the parts which it contains: the windpipe is a passage commencing at the back part of the mouth, and thence descends along the neck to open into the lungs; at its upper part it is constructed of five thin cartilages,

connected together by ligaments, and put into motion by small muscles. These cartilages form a kind of chamber at the head of the tube, which is situated at the root of the tongue, and may be felt to project in the upper and fore part of the throat. The opening of this chamber into the throat is a very narrow chink, which is dilated and contracted to produce every change in the modulation of the voice, by the muscles attached to the cartilages. To defend this opening, a beautiful contrivance is adopted of an elastic valve, which falls flat upon it whenever we swallow, like the key of a wind instrument; and which at other times rises up and leaves the aperture uncovered for the uninterrupted ingress and egress of the air into the lungs.

The tube leading to the lungs is formed by numerous semicircular cartilages, connected by muscular fibres and membranes. They are elastic and firm, to keep the canal of the windpipe always open, and to resist compression: at the same time it is nearly as flexible as though it was wholly membranous, and gives way to all the bendings of the neck: had it not been so, we should have been in perpetual hazard of strangulation. The passage to the stomach, or the gullet, on the contrary, being intended only for occasional use, has its sides always collapsed, unless when distended by

the passing food. The lungs are two cellular bags for containing air; they are situated in the chest, and both open into the bottom of the wind-pipe; but of these we shall speak more particularly, when we shall have occasion to view them as organs of respiration.

In inspiration the air dilates the lungs; these, like bellows, force it back in expiration into the wind-pipe, which may be compared to the pipe of an organ (as, indeed, may be the whole apparatus of speech to a musical instrument): here the air is straitened in its passage, and made to rush with force along the tube towards its upper end, where striking against the elastic cartilages of this part, it is variously modulated, and the sound of the voice produced. But these cartilages do not articulate the sounds; to effect this, the voice is required to pass through the mouth, where it is differently modified by the action of the tongue, which is either pushed against the teeth, or upwards towards the palate, detaining it in its passage, or permitting it to flow freely, by contracting or dilating the mouth. It has been ludicrously, and, perhaps, not improperly remarked of the tongue, that it is the only muscle under the controul of the will which is not wearied by incessant use.

Speech is a high and distinguishing prerogative of man; for though there are animals who also

emit sounds expressive of their wants and desires, and even some whose voice is so finely formed as to produce the most exquisite tones, as in the singing of certain birds; yet man is the only being with whom those sounds are not debarred an extensive combination, but can be modified by articulation into that infinite variety which constitutes the numerous languages of the earth. By this noble faculty are we enabled to express all our feelings and inclinations; to communicate our thoughts, and blend our energies, our knowledge and discoveries with those of others. In written language, form and permanence are given to evanescent sounds: the ideas and the improvements of one age are handed down to a succeeding one. The superior acquirements of one country are scattered over distant regions, and knowledge, civilization, and happiness, are diffused far and wide. Whatever superiority, in these respects, we have to congratulate ourselves upon in comparison with those who have preceded us in existence; their embodied labours have greatly contributed to it, and we, in our turn, shall add to the sum of intellectual improvement still to be accumulated as it rolls onward into futurity. Since language has elevated us to the present state of civilization, in opposition to the disadvantages it has had to struggle with from its want of unifor-

uniformity: now that a refined and systematic language is used by large assemblages of men in every quarter of the globe, a freer circulation of thought must take place; the language itself will improve, and both arrive at a point of perfection greatly surpassing that of the present day.

OF THE

BLOOD.

Having now described those parts of the human body on which its figure, support, strength, motion, sensibility, &c. immediately depend; we next come to those which are intended to replace the waste of the machine, and to supply it with new energies. Like all other animal matter, the human body suffers a constant change: life itself is an action inducing change, and which ultimately leads to death; and while life and health endure, this change is continually taking place, a removal of the old, worn out particles, and an incessant deposition of new ones. To effect the latter purpose, then, it is necessary that there be a provision of nutritious matter lodged in the animal machine, otherwise it must speedily wear down, and run into dissolution: we, therefore, find it plentifully supplied with a rich store of a nutritious fluid, fine enough to penetrate its minutest parts, and constantly circulating through the whole of the machine.

This fluid is called blood, and is of a rich and beautiful colour; it is of a vermilion colour in the arteries, of a modena red colour in the veins, and black, or almost so, at the right side of the heart. In various individuals, but much more so in dif-

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ferent animals, it varies with their functions and manner of life; it is more or less perfect in quadrupeds, in birds, in fishes, and in insects; it is thick or thin, has gross particles or small, is red or pale, hot or cold; and accordingly the last circumstance is so striking, as to have led to a division of animals into those of hot and cold blood. We shall afterwards trace a close connection between the temperature of that fluid, and the respiration of the animal.

Blood recently drawn from a vein into a bason, would seem to be a homogeneous fluid of a red colour; but when suffered to rest, it soon coagulates, and divides into two parts, viz. a red clot or cake, and the transparent serum or water in which it floats. The former may be again divided by washing away the red particles, when a pure and white coagulum only will remain.

In the blood of all animals, even in colourless insects, globular particles are found; in white ones they are white, in those which are green they are green also, but in most insects they are transparent. These red globules are easily seen in the human blood by the help of a simple lens; they are larger in the fœtus than in a grown animal, and also vary in size in different creatures. In the skate the red globules are much larger, but in the ox smaller than they are in man. Fish have

large globules, serpents smaller ones, and man smaller still. In man the diameter of each globule is much less than the three thousandth part of an inch. Their quantity, in regard to the whole mass, varies so much, that the appearance of the blood is a real index of the state of the constitution. In some diseases attended with weakness the blood is poor and colourless, in health and strength it is rich and florid: by labour the red particles may be increased in a wonderful degree; in hard working men they abound; they may be accumulated by exercise into particular parts, as in the wings of moor-fowl or pigeons, and in the legs of common hens: while their wings being rarely used, the muscles which move them contain but few red globules, and are of a paler tint. The colour of the flesh of animals is altogether derived from these particles, and if they are removed by repeated bleedings, it becomes unnaturally white; this effect of bleeding is well known to the feeders of calves. The uses of the red particles are not ascertained; but their colour depends upon the action of the air in respiration. They are found to contain some iron in their composition.

The coagulated mass which remains when we have washed away the red particles, is named coagulating lymph, from its tendency to become solid when removed from the circulation, or after the

death of the animal. This tendency is less in some circumstances than in others; more particularly in inflammatory disorders, and hence it is that when people labouring under them lose blood, it coagulates so slowly that the particles have time to subside to the bottom of the vessel, leaving the blood of a buff colour at its upper surface. This seems to be the most useful and nutritious part of the blood, and is the most universally diffused in the animal system. It enters into the composition of all the solids, and probably of the fluids. The chemistry of animal bodies is at present in a very imperfect state, but as far as we can judge, the muscular solid seems to consist wholly of this substance, and that with very little change; it certainly resembles it in many circumstances. When washed it is white, insipid, tenacious, and very fibrous, so that it can be drawn out to a great length. When slightly dried, it shrinks into a substance like parchment; when hardened by heat, it becomes of a horn-like texture; and when burnt, it gives a strong disagreeable smell like other animal bodies. Its analysis proves it to be the most perfectly animalised part of the blood, and the most ready to be assimilated with the living solids.

It has been called gluten, and more lately fibrine; both terms are taken from two of its most striking qualities. The elements of its composi-

tion are furnished by all our food, and many parts of vegetables, particularly the flower of wheat, contain a substance closely analogous to it.

How this gluten is applied and incorporated with the different parts of the body we are at present unable to point out, but we know from analysis that it is the basis of all the muscular parts of the animal body. When a muscle is wasted by violent action, or by fevers, or by long confinement is absorbed, gluten is deposited to supply the loss. In the other solids, and in the fluids, it enters less principally into their formation, but it adds its due proportion to their composition, and thus is found to have a most extensive share in forming, supporting, and renovating every part of the machine. The serum, or that portion of the blood which remains fluid, consists of two parts; the one coagulable by heat, and forming a whitish substance similar to the white of an egg; hence it is called albumen: like the gluten, it is not again soluble in water when once coagulated, unless it has been long boiled in a digester, when it is found to have lost all its other properties. It has been supposed that this substance is a preparatory step to the formation of gluten, and intermediate between the aliment and the solids. We cannot trace it in any of the solids of the animal body; though it is found in some secretions. When the albumen is

cut into slices a liquor exudes from it which differs from most animal bodies, and resembles vegetable mucilages and gellies; hence it is called the animal gelly. Like them it becomes sour if long kept, and does not putrify as the other parts of the blood do.

It is found in many of the solids which seem principally formed from it, as the cellular substance in all its shapes, and is more abundant in young animals than the old.

It is not coagulable by heat, but is soluble in water, and more easily in warm than in cold water; hence when the solution is cold it is left in a trembling mass. It is well known in domestic economy, and is nearly the same substance whether procured from the feet of calves, hartshorn, or isinglass, which last is prepared from fishes.

The blood contains various saline particles, and the earth which assists in forming bones; but of its other properties, and more particularly those which are derived from the air in respiration, we defer speaking till we shall have occasion to view the nature of this fluid, and its influences on the animal body. We shall now describe those parts which throw the blood into motion, sustain its constant circulation throughout all the parts of the body, and which separate various fluids of different properties from the blood.

OF THE

ORGANS OF CIRCULATION.

THESE are the heart, the arteries, the veins, the absorbing vessels, and their glands.

Of the Heart.

This noble and principal organ of life, is generally known as to its figure and appearance; it is situated nearly in the centre of the human body, occupying a place in the chest rather to the left of the centre of this cavity, and lying immediately upon the diaphragm or muscle dividing the chest from the cavity below, with its apex or point inclining towards the bony extremity of the sixth rib of the left side, and against which it may sometimes be felt to strike. In this situation the heart is sustained by the large blood-vessels which originate from its base; but its point is entirely free, and it is surrounded by a strong membranous bag or purse, which is firmly fastened to these vessels, and to the diaphragm. It serves to preserve the moisture of its surface, by constantly exuding a fine thin lubricating fluid, and thus lessens its friction with the parts in contact with it; at the same time that it supports the heart itself when under violent action.

The heart is hollowed out into four cavities or chambers for receiving the blood, and for giving it a fresh impulse. Two of these cavities are on each side, and communicate with each other by an opening through the partition which divides them; but they are totally distinct from the cavities on the other side, although they correspond with them in shape, structure, and use. The heart may be said, therefore, to consist of two distinct organs; one on the right heart for sustaining the circulation through the lungs, and the other on the left for impelling it through the rest of the body. The first cavity on the right side of the heart is called its auricle, and receives the terminations of two large veins which reconvey the blood returning from all parts of the body to the heart. This cavity may be viewed as a reservoir for receiving the returning blood, which it discharges into the other cavity of the same side, called the right ventricle. The opening into the ventricle is closed by a valve, which is so contrived as to admit the blood, but to prevent its return. The ventricle has another opening leading from it into an artery, and the right ventricle when filled with blood from the auricle, contracts and forces it into the artery of the lungs; and that it may be able to propel the blood with sufficient force into this tube, it is constructed of greater strength

than the auricle, having its walls firmly supported by fleshy columns, which extend across the cavity of the ventricle, and connect its opposite sides together. There are valves also situated at the commencement of the artery of the lungs, and for the same use as in the auricle, viz. to prevent the blood from returning into the cavity, whence it had just been expelled.

This description of the right side of the heart will suffice for that of the left; both being constructed nearly in the same manner, having corresponding cavities or chambers, and for similar purposes. But it ought to be observed that as the right auricle receives the blood returned to the heart from all the parts of the body; and the ventricle of the same side propels it into the vessels of the lungs; so the auricle on the left side of the heart receives this blood from the lungs, by four veins which open into it, while it is the office of the left ventricle to force it into a new circulation along the extent of the whole body. The left ventricle is stronger than the right, because it has a greater resistance to overcome.

The substance of the heart is muscular, being composed of red and elastic fibres, similar to those which constitute the other muscles of the body; but so arranged as to admit of contraction in all directions, and with such a peculiar modification of the irritable

principle as to be contracted and dilated alternately through the whole of life; so that the circulation never ceases. The heart in fact possesses the contractile power in a higher degree than any other muscle. It is called into action partly by the mechanical distention of the blood, although principally, no doubt, by its peculiar qualities as a stimulus. The auricles of each side are filled at the same instant, while the ventricles are at the same time emptying themselves. The right auricle, when filled, contracts, and urges the blood onward into the now relaxed ventricle; the last when distended contracts in its turn; the flaps of the valves are thrown back, and close the opening into the auricle, and the blood has no other outlet but into the pulmonary artery which leads to the lungs; where it is to be changed in its colour and other properties. The artery is now dilated, its valves are instantly closed, and prevent the return of the blood into the ventricle. Then the artery contracts, and impels its contents onward, to make way for a new wave of blood. During this time corresponding motions take place in the left side of the heart, with this difference only, that the left ventricle forces the blood into the aorta, or great artery of the body, after it has undergone its due changes in the lungs, through which it was circulated by the force of the right ventricle.

It is observable, that this motion of the heart not only survives that of the organs of voluntary motion, but continues a considerable time even after it is separated from the body. Nay, after it has ceased to palpitate, yet, as it still retains a latent power of action, its contraction and dilatation may, by the application of stimuli, be alternately renewed and continued some time longer. Hence in drowning and suffocation, though the pulse be imperceptible, and life apparently extinguished, yet the heart still preserves this latent power, or susceptibility of motion; for though unable to propel the blood through the vessels of the body, yet it wants only to be excited by suitable stimuli to renew its action. In the first rudiments of life, even before the brain is formed, a pulsating point or spot shews the embryo heart in miniature, and marks its primæval irritability, as a sure pledge of vitality. The heart of the chick begins to move before we can presume that there is any organ for distributing the nervous power. The palpitating point is the heart of the chick, and it is seen beating while its body is but a rude, unformed, and gelatinous mass.

As this singular organ exhibits irritability the first, so it never relinquishes it till the last, and may therefore be considered as the first part of the animal which lives, and the last to die.

In animals with cold blood, this irritability is very great, and continues a long while. The heart of a viper will palpitate when taken from the body twenty-four hours, and that of a turtle, thirty, or longer. In the warm-blooded animals, it moves till the fat is rendered stiff by the cold, at which time the motions of the heart and all the other muscles commonly cease.

Of the Arteries.

From the ventricles of the heart arise two large elastic tubes, called arteries, and which afterwards divide like the trunk of a tree, into innumerable branches. The one commencing at the right side of the heart, conveys the blood to the lungs, while that which is continued from the left ventricle, carries it to all the other parts of the body. The arteries are composed of three membranes called coats, an external coat, a middle coat, which is muscular, and an inner one, which is smooth. They partake of the nature and action of the heart, for being dilated and irritated by the blood impelled into them from the heart, they contract, by means of their muscular coat, upon this blood, and thus propel it to all parts of the body for their nutrition and the various secretions. This dilatation and contraction is called the pulse, and is perceptible in the trunks and branches of the arteries,

but not in their minute ramifications, except when inflammation is going on.

Of the Veins.

The blood, having been conveyed by the arteries, even to the extreme parts of the body, for its nourishment and repair, requires to have the surplus carefully returned to the heart and lungs, to be prepared for a new circulation; and for this purpose are the veins provided. They commence from, or rather are continuous with the minute arteries, and as they approach the heart, they run into larger but fewer tubes, till at last they terminate in it by six great trunks. Two of them empty their contents into the right auricle; the one collecting the blood from the vessels of the head and the upper extremities, while the other ascends with it from the lower parts of the frame. These are loaded with venous blood: but the remaining four veins pour the blood from the lungs into the left auricle; it is now changed into a bright red colour, and is called arterial blood, because it has the appearance with which it is always found in arteries; so that in the lungs the office of the arteries and veins is transposed; the former conveying venous blood, while the latter are filled with arterial blood.

The continuation of the extreme branches of

the arteries to those of the veins, resembles two trees united to each other at their tops, while their trunks are so disposed as to terminate in a common point, the heart; and if we suppose that both these trunks and their ramifications are hollow, and that a fluid is incessantly circulating through them, by entering into one of these trunks, and returning through the other, we can conceive how the blood is circulated through the human body.

The veins do not pulsate, like the arteries; the blood which they receive from these vessels flows through them very slowly, and is conveyed back to the heart by the current of blood from the arteries, and the contraction of the muscles, among which they ramify. It is prevented from flowing backwards in the veins by valves, which constitute one of the great distinctions between these vessels and the arteries. The valves are formed by the innermost membrane of the vein rising up in a fold into the cavity of the vessel like a curtain, and stretching itself along the vein so as to form a kind of crescent, which permits the blood to flow on towards the heart, but immediately stops it if attempting to regurgitate.

Of the Absorbents.

We have seen above that many arteries terminate in veins; but it is impossible for us to scrutinise the minuter operations of nature in animals; or to say how it is that from one fluid such an endless variety of substances should be formed, as the solid and fluid secretions in animals exhibited to our view. Each of these must require a different apparatus, and hence, no doubt, the terminating branches of arteries are variously modelled in the organs which create bile, or fat, or any other secretion. Still we cannot point out how they vary; but are compelled to say, in general, that they terminate in the glands.

Other arteries take a simpler and more obvious course, and are to be found with their extremities opening upon the different surfaces of the body. These are numerous, and are called exhalents, because they emit a very thin, watery fluid, or vapour, from their mouths; for the purpose both of keeping the sides of the internal surfaces moist, and preventing friction. And as this vapour is constantly exhaling into all the cavities of the body, if there were not other vessels to absorb this fluid, and reconvey it into the circulation, these cavities must soon be filled with water, as in

dropsy, and disease be produced; to prevent which the supreme architect has furnished us with a set of vessels which are so peculiarly organized, as to take up the superabundant water, and convey it again into the circulation.

The absorbents are thin and pellucid vessels arising from the various surfaces of the body, and running to a common trunk or tube, called the thoracic duct, because it lies principally in the thorax or chest, which empties itself into a vein a little before it comes to the heart. They are distinguished into two kinds, the lacteals and the lymphatics; the former absorb the nutriment from the intestines, and convey it by the thoracic duct into the circulation, as we shall hereafter more fully explain; while the latter vessels take up the colourless fluid, called lymph, whence they have received their name; and convey it from all the parts of the body to the same point. Thus the parts of the blood which either from their thin, oily, or nutritive qualities, had been separated from the red, circulating mass, and thrown out by the secreting or exhaling arteries, are absorbed, after having performed their various uses, and are again conducted by the lymphatic vessels back into the circulation to mix with the blood; and the lacteals, or absorbing vessels of the intestines, drink up the milky fluid formed from our food, and carry

it to the heart and lungs to be changed into blood.

Hence we see that absorption is a function necessary to the circulation, and highly essential to life; it compleats the circle in which our fluids move, and supplies the constantly decreasing blood with new parts: but there are other purposes, which this curious and beautiful operation of our frame accomplishes. The skin is full of small pores which are the mouths of lymphatic vessels, through these are absorbed properties from the surrounding bodies, as from the air, water, or such substances as may be in contact with the skin, and are thence conveyed into the system for its refreshment, or cure; thus we know that medicines rubbed on the skin enter the body, and affect the frame.

But a grand, constant, and universal agency of our lymphatic system, is the removal of old, useless, and worn out parts, and the making room for new ones: this astonishing and noble power of our frame to change its withered, for sound, healthy particles, is not confined to any one part or organ of the body, but is possessed by all. Delicate membranes, and strong tendons, the soft moving muscle, and the hard, solid, inactive bone, are all acted upon by these modellers of our frame, throw off the old exhausted particles of which

they were composed, and acquire fresh ones. By this constant and general renovation of all its parts, which endures through life, are the health and vigour of the whole body preserved.

Absorption also helps to remove those injuries which happen to the frame by accidents; if a tumour arises from a blow, the absorbents will soon begin to act, and in some time will remove the swelling. A fluid poured from its ruptured vessel will be absorbed by the lymphatics, and carried again into the circulation. Even parts of the body which are diseased, or have their organization destroyed, and are consequently unable to perform their functions, will have their dead particles carried off by absorption, and room made for fresh, healthy depositions. The black or greenish spot which is left by a bruise, is owing to blood having exuded from a ruptured blood-vessel; its disappearance is the effect of the action of the absorbents, which is at all times, and in a similar degree, operating in every part of our body, but not equally obviously. According to the proportion which the action of the absorbing vessels bears to that of the arteries, by which fresh supplies of nourishment are brought to all parts, will the size of the body depend; hence in youth the absorbents depositing more nutritious matter than the arteries convey away, the frame grows and expands. In middle age

there being a balance between the actions of the two systems of vessels, no change can take place; but the absorption being greater in old age than the nutritious action of the arteries, now declining agreeable to the course of nature; the body at this period shrinks from its usual dimensions, the limbs become wasted and shrivelled, and the whole frame totters towards the grave.

The absorbents are full of valves like the veins, for preventing the regurgitation of the lymph, and the power by which they drink up this fluid, and with it the decayed and dissolved solids of the body, is supposed to depend principally on their muscular structure; the mouths of these vessels being filled by capillary attraction with the particles of the fluid, their coats contract, and their contents being pressed upon at the sides, and prevented returning by the valves, are necessarily propelled towards the termination of the absorbents in the veins, there to be mixed with the blood.

Of the Glands.

These organs are designed to separate various substances from the blood, and are situated in different parts of the body: they differ in size, shape, and construction, according to the peculiar kind and quantity of fluid which is meant to be separated from the mass of blood: thus while some are

small and of a roundish figure, there are others much larger and variously formed. Each of the small glands consists, first of an artery for supplying the gland with blood, and also for separating, by the peculiar disposition of its extremity, a particular kind of fluid from this blood; next of an excretory duct or canal which goes out of the gland, and conveys out of it the secreted fluid, by the contractility of its coats; and lastly, of a vein for returning to the circulation, the blood remaining after the secretion has been accomplished.

Of this simple kind are the generality of those little glands, which are found in different parts of the body, as under the skin, in the mouth, nose, eye, &c. and which, by secreting an oily or mucilaginous fluid from the blood, keep the parts on which they lie constantly moist, prevent friction, defend them from the air, and the extraneous bodies it may contain. That the vessels necessary to effect secretion may not be extended out into long and inconvenient lines, which would cause them to occupy more room, and render them liable to interruption; they are artfully coiled up into a small space, and connected together by cellular substance, so as to assume the roundish and even appearance, which those little glands exhibit.

The large glands consist principally of an aggregation of the small ones, but have these peculiarities of general structure; first that all the arterial branches which bring the blood to the gland, and afterwards become the organs of secretion, arise from one great trunk, which does not divide till it has reached the body of the gland; next, that the excretory ducts of the various small glands, composing the great one, all run to unite into one large, common tube or canal for conveying away the collected secretions of the little glands; and lastly, that the branches of the veins, corresponding with those of the artery, all pour their blood into one great trunk, by which it is returned into the circulation.

This process of separating various bodies from the mass of blood is termed secretion, and it is a most important function; for in fact every animal production is a secretion, whether there be a complicated apparatus for forming it or not. Thus bone, flesh, fat, skin, &c. are as strictly secretions as is the urine, or the bile, or the tears: only that in the latter case, for the sake of compactness, or because the secretion was wanted in one spot for a specific purpose, the apparatus for producing it is limited: while in the other instances, the substances are formed in many parts of the body.

The term gland has been confined to the con-

geries of vessels, &c. above described; but we have just seen that parts the least peculiar in their structure perform the functions of a gland. The glands themselves will be individually described in treating of the parts in which they are lodged, or of the uses to which they are applied.

In general the substances they secrete are of immediate use in the animal system, and are so either constantly or occasionally. In the latter case, a reservoir is attached to the gland in which the secretion is accumulated till it is wanted.

There are other secretions which separate useless or noxious bodies from the blood; these are termed excretions: such is the urine, the perspirable matter, and some others. They are the vehicles by which worn out particles are removed, as well as noxious ones.

The manner in which the glands effect secretion is wholly unknown. They are composed of similar vessels, have a common fluid to secrete from, and still they separate substances wholly differing from each other and from the blood.

We know that the secretions are not previously existing in that fluid, although their elements are. We have seen, indeed, that there are some striking resemblances between the gluten of the blood and the muscular fibre. The tears also, and the liquid

which is poured out on the internal surfaces of the body, are somewhat similar to the serum; but the bile, the fat, the urine, and many other secretions, are totally unlike to any thing in the circulating fluid. We are taught by modern chemistry, that all animal and vegetable bodies are resolvable into a few simple ones. We know too that a slight variation in the proportion of the ingredients of a compound body, and such are all animal substances, will totally change the character of the new formed matter. A little reflection will convince us how indefinitely any four quantities may be combined together; and having connected these circumstances, we shall cease to wonder at the variety of forms which animal substances assume.

This, however, is very vague and unsatisfactory knowledge; the mechanism is far too minute for our inspection; and it never will be in our power to examine the machine when at work; all our observations must, therefore, be confined to the dead body. Hence we can have but little hope of penetrating into this mysterious process, although we may conceive in general, that vessels of different sizes, lengths, convolutions, and angles of separation from their trunks, will be fitted to deposite different compounds. In fact, we find that the body of man is a complicated laboratory, where

changes are incessantly taking place, partly of a chemical, and partly of a peculiar nature, resulting from the principles of life.

REVIEW OF THE CIRCULATION.

The celebrated Harvey was the discoverer of the circulation of the blood. " Seeing, says he, that the blood passed from the arteries in abundance into the veins, unless these were to empty themselves, and the others to be refilled, that ruptures of vessels every where would take place, which does not happen, I began to conjecture there must be a circular motion of the blood; but this doctrine was so new and unheard of, that I feared much detriment might arise from the envy of some, and that a number would take part against me, so much does custom and doctrine once received, and deeply rooted, pervert the judgment. However, my resolution was bent to set this doctrine forth, trusting in the candour of those who love and search after truth."

Accordingly, no sooner had this great man published his discovery of the blood's circulation, than prejudice levelled its enmities against him; few physicians, and none passed the age of forty,

believed in his doctrine, which they stigmatized as an herctical innovation in philosophy and physic; and even his practice began to decline. But he had the happiness to outlive the clamours of ignorance, envy, and prejudice, and professional men grew at last ashamed to own that they had ever combated or disbelieved the circulation of the blood. The doctrine taught by Harvey is,

That all the veins of the body running into two great trunks, viz. one ascending from the lower part of the frame, and the other descending from the head, and superior limbs, empty themselves into the right auricle of the heart. The right auricle unloads into the right ventricle of the heart, which throws the blood through the pulmonary artery into the lungs by its two branches, which go to the right and left lobes. From the lungs the blood is brought back by the four pulmonary veins into the left auricle, and from thence it passes into the left ventricle, by which it is distributed through the body by means of a great artery, called the aorta, and its branches. These terminate in the veins of the body which collect the blood, and bring it back to the heart again by the two great trunks already mentioned.

Thus there is a double circulation of the blood constantly going on, one from the heart through the lungs, for the purpose of the blood's receiving

certain properties from the air; and another from the heart, over all the parts of the body, that it may give out its nutritive and vital properties to the whole of the animal machine.

The circulation of the blood can be easily seen, by the help of a microscope, in the bodies of different creatures, which are either wholly, or in part transparent; and the observations made by this means are preferable to any others we can have recourse to, since, in dissections, the animal is in a state of pain, or dying; whereas in animals thus viewed, all is left in its usual course, and we see what nature does in her own undisturbed method. The tail of the newt, or water-lizard, affords a very entertaining prospect of the circulation of the blood, through almost numberless small vessels: but no object shews it so agreeably as one of those animals while so young as not to be above an inch long; for then the whole body is so very transparent, that the circulation may be seen in every part of it, as well as in the tail; and, in these objects, nothing is more beautiful than the course of the blood into the toes, and back again, where it may be traced all the way with great ease. Near the head there are also found three small fins, which afford a very clear view of the circulating blood. These are all divided like the leaves of the polypody, and, in every one of their branches, the blood

may be very accurately traced, running to the end through the artery, and then returning back again by a vein of the same size; and as the vessels are very numerous and large in this part, and the third or fourth magnifier may be used; there are sometimes seen thirty or forty channels at once. The large size of the globules of blood in the newt, and their fewness in proportion to the quantity of serum, renders them particularly distinct; and we remark that their figure, as they are protruded through the vessels, changes in a very surprising manner.

The impetus, occasioning the circulation, is great enough in some animals to raise the blood six, seven, or eight feet high from the orifice of a divided artery; and that the force of the heart must be very great, appears also from its expelling about eight pounds twelve ounces every minute, with a velocity equal to one hundred and fifty-nine feet in that time, besides overcoming a great resistance in distending the arteries. The space of time wherein the whole mass may ordinarily circulate, is not ascertained. Some of the latest writers, however, state it thus: Supposing the heart to make two thousand pulses in an hour, and that at every pulse there is expelled an ounce of blood, as the whole mass is not ordinarily computed to exceed twenty-four pounds, it must be circulated seven or eight times in the space of an hour.

Such is the circulation of the blood; and the astonishing arrangement and powers of its organs. Whether we consider the force which they exert, their never wearying action, or the admirable wisdom with which they are disposed, the subject forcibly seizes the mind, and the attention is arrested by this most striking of the animal functions. Far less magnificent in their plans, less skilful in their execution, hydraulics offer us but faint analogies with it, in those machines by means of which water is distributed into every quarter of a great city. In the whole contrivance of the circulation we may truly say that the creator has impressed upon it a stamp of nobleness, and of excellence, which demonstrates its divine origin.

EXPLANATION OF PLATE III.

This Plate represents the principal Blood-vessels, both Veins and Arteries. The latter are seen in shade; the Veins are traced with a lighter stroke of the engraver.

The fore part of the Trunk is removed, the principal contents of the Chest, and the Abdomen, are dissected away; as is the Skin and the Cellular Substance from the Extremities.

Sec. 1.—General Description of the Arteries of the Trunk.

Fig. 1.

The Heart (1) is observed in its natural oblique position, with its Base towards the right, and its Apex towards the left side. The right Ventricle is seen in front, with the Pulmonary Artery (2) rising from it, which is cut off above its origin. The right Auricle (3) is perceived on the right of the Pulmonary Artery, and its division from the Ventricle, is marked by an irregular line nearly parallel with the Base.

A small part only of the left Auricle is now brought into view on the left of the Pulmonary Artery, and the left Ventricle is immediately behind the right. The Aorta is seen in deep shade, sending off 3 large branches at that part where it forms a bend. These branches are, the common trunk of the right Carotid, and the right Subclavian Arteries;

The left Carotid; and

The left Subclavian.

The Carotids supply the Head and Neck; each divides into an internal and an external branch. A few only of the external branches are here seen, for those vessels which are spread upon the Face and Neck, are chiefly Veins, which are in all parts of the Body more numerous than the Arteries. The Aorta, after forming the arch, descends on the left side the Spine, giving off Arteries to the Diaphragm, the Liver, the Stomach, Intestines, Kidneys (4), and Testicles. Just below the Kidneys (4) it is seen to divide into two large vessels, the Iliac Arteries, which again branch into two other vessels, the internal Iliac Arteries supplying the parts within the Pelvis, as the Bladder (5), &c. The remaining branch on each side comes out at the Groin, where it can be felt beating strongly. Then it divides into two branches, the external one (6) dips deeply into the flesh of the Thigh, to supply its upper part. The continuation of the inner branch (7) is seen in fig. 2.

Sec. 2—Arteries of the Thigh and Leg.

Fig. 2.

Just above the middle of the Thigh it passes from the fore to the back part, to be lodged securely in the Ham, in order to

descend to the Leg. It afterwards separates into two branches, one of which only is seen in this view (8). Both of them supply the lower part of the Limb.

Sec. 3.—Arteries of the Arm and Hand.

Fig. 1.

The Subclavian Artery is seen on the right side just below the Arm-pit, forming the Humeral Artery (9), which divides at the Elbow into two other branches, not distinctly traced in this view. These are the Arteries which supply the Fore-arm and Hand. One of them is felt pulsating at the Wrist (10).

Sec. 4.—General Description of the Veins.

Fig. 1 and 2.

The Veins of the Fore-arm are seen in numerous branches, and collect into fewer trunks at the bend of the Arm, where the operation of bleeding is performed (*a*). Then their course is principally on the inside of the Arm. A principal trunk (*b*) is seen on the left side the figure, forming the Axillary Vein. Having received many smaller Veins it becomes the Subclavian (*c*), on the right side. This receives the Veins from the Head (*d*, *d*), by two large trunks, the internal and the external Jugular Veins. The external Jugular of the right side (*e*), which is often seen to swell out when breathing is interrupted by coughing, &c. These carry the Blood from the outside of the Head; the internal Jugulars carry back the greater part of the Blood which has circulated in the Brain. The Subclavians of each side having united with the Jugulars, (and just at that point the Chyle is poured into the Veins by the Thoracic Duct) themselves join their currents, and form the descending Vena Cava, run immediately above the number 3 upon the right Auricle, behind which it meets the ascending Vena Cava (*f*), to pour their contents into that Auricle.

The Veins of the Leg and Thigh are principally seen in the inside of the Knee (*h*, Fig. 2) being collected from the net-work of Veins upon the Foot (*g*, Fig. 2). The continuations of the principal trunks are seen at (*i*) Fig. 1, and (*k*) in the inside the femoral Artery. These unite at the Groin, and form the Iliac Veins. The Iliac Veins of each side join immediately below the division of the Aorta, and form the great Vein of the Body, the ascending Vena Cava. This is seen to receive Veins from the Kidneys, and a small one which can be traced to the right Testicle, receiving a small Vessel from the Aorta, which is the Artery of that Testicle.

The Blood-vessels of the Testicles are connected together by cellular substance, and come out of the Abdomen at the Groin. The left Vein of the Testicle is seen to terminate in the corresponding Vein of the Kidney. The ascending Cava passes

upwards behind the Heart, receiving in its course at (*f*), several large Veins from the Liver, and pours its contents, in common with the descending Vena Cava, into the right Auricle.

Fig 1, and 2.

1. The Heart.
2. The Pulmonary Artery.
3. The right Auricle.
4. The Kidneys.
5. The Bladder.
6. One of the large Arteries of the Thigh.
7. The Femoral Artery continued at (7) Fig. 2.
8. A principal Artery of the Leg.
9. The Humeral Artery.
10. The Artery at the Wrist.

a. The Veins of the Fore-arm.
b. The Axillary Vein of the left side.
c. The right Subclavian Vein.
d. Veins of the Head.
e. The right Internal Jugular.
f. The ascending Vena Cava.
g. (Fig. 2.) A Plexus of Veins on the Foot which unite to form a principal Vein of the Leg (*b*), Fig. 2.
i k. Principal Veins of the Thigh continued.

OF THE

ORGANS OF RESPIRATION.

We now come to one of the most beautiful and important functions of the animal body; a function on which life itself immediately depends, and which is constantly replenishing all its springs. Breathing, like the circulation of the blood, is essential to the preservation of the animal: the one supplies it with fresh nutriment, and by that means prevents a decay; the other animates the whole of the machine, and invigorates all its movements. But to comprehend this noble function, it will be necessary to extend our views to the nature and properties of the air engaged in respiration, and afterwards to those influences which it has upon the animal body. We shall first, however, describe the organs of respiration, and the manner in which it is performed in man, and in other creatures.

Of the Trachea or Air-tube.

The trachea, or wind-pipe, by which the air is conveyed from the mouth and nostrils into the lungs, has nearly the same construction in quadrupeds as in man. It is formed of cartilaginous rings, and an elastic ligamentous membrane; the

rings are intended to keep the area of the tube constantly open, but do not describe a circle, the back part of the wind-pipe, or that side of it which lies next to the canal leading from the mouth into the stomach, being composed almost wholly of the elastic membrane, for the greater convenience in the act of deglutition. This membrane also connects the cartilaginous rings together, and completes the sides of the tube. The upper part of the trachea, as we have before observed, is peculiarly formed for producing the voice, and has a small thin cartilage placed over the mouth of the tube, which occasionally shuts down, and closes the passage to the lungs, as in swallowing. From this part the air-pipe descends along the fore part of the throat, till it passes into the cavity of the chest, to enter, and be ramified, through the lungs; its internal surface is constantly kept moist, and defended from the air when passing through, by a mucus which is poured out from small glands every where strewed on the membrane lining this tube. A similar mucus lines all the passages which lead to the internal cavities from without.

When the air-pipe has nearly reached the lungs, it divides into two great branches: one of these goes to each lung, and is distributed through the whole of its substance, in an infinite number of ramifications, all constructed in a manner similar

to the original tube, till they become very minute; when instead of having cartilaginous rings, they are found to be wholly membranous. These small branches terminate in innumerable cells, which communicate with each other, and give the lungs the appearance of a honey-comb when its substance is cut into, particularly in some animals where the cells are large; as in the turtle.

Of the Lungs.

We have had occasion already to observe, that the trunk of the body was divided into two great cavities by the diaphragm, which is a horizontal fleshy partition, and that the superior cavity was called the thorax or chest, and contained the heart and organs of respiration. This cavity is again divided into two lesser ones, by a strong membranous partition, which runs in a direction perpendicular to the diaphragm, and extends from the back-bone to the fore part of the chest: it is composed of the membranes lining the two cavities, which being applied to each other laterally, like two bags, form a partition for separating and sustaining the lungs, and also preventing them from pressing upon each other, in the different positions of the body. The laminæ composing this partition do not every where adhere together, for at the lower part of the chest they

recede from each other, to make room for lodging the heart, and at the upper part of the cavity they receive between them a gland called the thymus, the use of which, in the animal œconomy, is not yet ascertained. The internal surface of the chest, like all other cavities, is kept constantly moist and smooth, for the greater safety of the delicate organs of respiration, by means of this lining membrane, which is called the pleura, and which exudes a fine watery fluid, preventing friction and adhesion of the lungs to the sides of the chest.

The lungs are the principal organs of respiration: they are two in number, one occupying the right, and the other the left cavity of the chest; but they respire by one common tube, the wind-pipe. Their texture, as may be seen in those of any quadruped, is soft and spongy, being composed of blood-vessels branching out with exquisite minuteness upon the sides of the air-cells; they are united into a mass of cellular membrane, and so disposed, that the blood can extract from the air certain properties which shall be hereafter explained.

Of Respiration.

Respiration consists of inspiration, or the ingress of the air into the lungs, and expiration, or the egress of the air from the lungs: it commences,

immediately after birth, and continues through life. In man and quadrupeds it is performed in the following manner.

The diaphragm, dividing the chest from the abdomen, is strong and muscular, and can act with great power in enlarging the cavity of the chest; it is convex towards the lungs, and concave below; when it contracts its surface becomes nearly flat, and of course the chest is deepened. At the same instant the intercostal muscles contract, and raise the lower ribs which are moveable towards the upper one which is more fixed. When the ribs are raised, they are so contrived as to be drawn outwards, and the cavity of the chest is dilated laterally.

Thus we see that when we inspire the chest is enlarged in all directions. The lungs are suspended in the cavity, and follow all the motions of the parts which enclose them, for when the pressure of the ribs is removed, the air they contain expands by its elasticity, and the external air rushes in to restore the balance. The lungs are now in a state of inspiration, and they are emptied by the following process.

When the diaphragm contracts, it would lessen the abdominal cavity as much as it enlarges that of the chest, if its loose enclosure did not give way by protruding.

This protrusion of the belly excites the abdominal muscles to re-act; their contraction pushes up the now relaxed diaphragm into the chest, and as they are attached to the lower edges of the ribs, they pull them down with great power, and thus lessen the cavity of the chest. The lungs are compressed, and the air which they had just received is now expelled. This is expiration.

It is curious to remark the admirable alternation of motion by which the mechanism of respiration is effected. The diaphragm and intercostal muscles co operate in enlarging the chest, they contract and are relaxed in the same instant: while the abdominal muscles seize, as it were, the moment of their relaxation to counteract their motion, and to diminish the size of the chest.

The function of respiration is performed in the mode above described: in animals which have a muscle, the diaphragm is for this specific purpose. Breathing is essential to all animals, though it is effected very variously in different creatures, in correspondence with that indefinite diversity of forms, and of habits, with which animal existence is endued.

Birds have no diaphragm, and their whole trunk may be considered as a chest; for besides their proper lungs, large air-bags are extended through their body, and communicate even with the inside

of their bones, which are hollow. These bags are moved by the ribs and breast-bone, and their aërial contents are blown through the lungs. Thus they have this function in greater perfection even than man or quadrupeds; for they consume more air, and at the same time they are rendered light to enable them to fly.

Amphibious animals can live long without respiring; they exhibit a less complicated system for the function, they have no ribs, no diaphragm, no chest in fact. The respiration of frogs will illustrate this; they breathe through the nostrils, and distend their throat with air; the muscles of the throat force it into the lungs, which are emptied by a slight motion of the sides of the creature. So that they swallow the air by their broad extended jaws, and come to the surface of the water to procure it only occasionally.

The lungs in these animals, and in lizards, the camelion, and even the crocodile, who all breathe in the same manner with the frog, are thin, delicate, transparent bags, with but few arteries and veins distributed upon them; which is the reason that they require the influence of the air in a slender degree only.

Fishes again have a mode of respiration peculiar to themselves. They breathe air when mixed with water, and this office is performed by their

gills. These are formed by tender membranous fringes, through every part of which the blood circulates. They are protected by broad flaps, which move, as it were, upon hinges. These fringes are separated when the fish opens its mouth and drives the water backwards by a motion of its jaws, so that it is forced between each feathery extremity of the red gills. Here the blood is exposed to the water and the air which is dissolved in it; for fishes can no more live in water deprived of its air by boiling, or by an air pump, than man or quadrupeds can live in a vacuum. If put into such water, they rise to the surface and gasp for air. Fishes cannot breathe in air alone, for that element is not accommodated to the mechanism of their lungs.

The breathing of fishes unfits water for that function, as air is corrupted by the respiration of man; if we separate the air from the water in which fishes have lived, it is no longer the same air it previously was, and it is contaminated precisely in the same way as air is which has been respired by man. Hence it is that fishes when confined in a small vessel rise to the surface, and that in frozen ponds they crowd around the holes which are made in the ice. Even shell-fish have a sort of gills for the performance of this function; and the beard of the oyster is a curious and admirable example of their structure.

The last species of animal respiration we shall notice is that of insects. They have no breathing organ like the lungs, but their bodies are pierced with air tubes in every direction. They divide very minutely like the delicate vessels of leaves and flowers, and penetrate every part of the animal; but the objects are so small, and the changes of form which insects assume are so rapid, that we cannot point out all the uses of this peculiar structure.

After the very cursory sketch we have given of the various modes of respiration, we can judge of the importance of this function to all living beings, from man down to the meanest reptile. We shall now examine those properties of the air which are so essential to the life of animals, what changes it undergoes from respiration, and what effects it produces on the blood.

OF THE

NATURE AND PROPERTIES OF THE AIR.

It will not be possible to explain the nature of respiration without prefacing it by some observations on the constitution of the atmosphere, and without illustrating our remarks by noticing some analogous operations, in which the air bears an important part.

Though our atmosphere may be compared to a great alembic, into which all the bodies of the earth are continually sending up a part of their substance, to mix, and float a while in common; where minerals from their lowest depths ascend to make a part of the general mass; where seas, rivers, and springs, furnish their copious supplies; where plants receive and return their share; and where animals, that by living upon, consume this general store, are found to give it back in vast quantities when they die: yet, notwithstanding this general admixture from various bodies, the operations which corrupt, and those which renovate the atmosphere, are so nicely balanced, that it is uniformly found to be composed of three elastic aërial fluids, never varying in their proportion, yet differing materially in properties from each other, when separately examined, and constituting when

combined one homogeneous fluid every where surrounding our globe, and which we denominate air.

Of these ingredients one only is much affected by respiration, namely, the pure or oxygenous part, which signifies acid making air, because when combined with certain bodies it forms acids. Every 100 pints of atmospheric air contain about 27 of oxygen. The azotic part is so named, from its not supporting life; it is found in larger proportion than the oxygen, namely, 72 parts in every 100; while carbonic acid, or fixed air, which is known to consist of charcoal combined with so much oxygen, as to be formed into an acid, is ascertained to exist in the proportion of one part only to every hundred. Still, as it is found in air collected on the summits of the highest mountains, as well as in that of level countries, it is justly considered a part of the atmosphere.

It was not until lately that the true nature of the air, and its effects on different bodies, came to be known. Formerly, indeed, philosophers were not ignorant that the air underwent changes from certain great operations; such as the combustion of inflammable bodies, the respiration of animals, and the calcination of metals. These alterations they wrongly supposed were owing solely to additions made to the atmosphere; but it is now

known that in all these cases the air is decomposed, the oxygenous part combines with the inflammable body, with the blood, or with the metal: so that the air is diminished in weight, and in bulk, while the burnt substance in the one case, and the metal in the other, is increased in weight exactly by that quantity which the air has lost. The blood too in the same way separates the atmosphere into its constituent principles, and robs it of its oxygen. We find that combustion, particularly of bodies which contain charcoal, is strikingly analogous to respiration. In both cases carbonic acid is formed, and the oxygen which has disappeared is to be sought for in this new formed substance.

OF WATER

AND ITS CONSTITUENT PARTS.

BEFORE, however, we come to shew the effects of air on the animal œconomy, it will be necessary to notice another splendid discovery of modern chemistry; namely, that water, that pure and apparently simple element, is composed of two distinct and different principles.

We have the most satisfactory proofs of this fact in the analysis and the recomposition of this fluid, although it would carry us too far to detail the experiments by which it is proved.

Every 100 parts of water consist of 85 of the oxygenous principle, and 15 of another not before mentioned, hydrogen, or that substance which constitutes inflammable air, and which forms a part of the blood, and indeed of all animal and vegetable substances.

The application of this curious and interesting fact will occur hereafter.

AIR IS NECESSARY TO LIFE AND MUST BE RENEWED.

How necessary air is to animal life, we have numberless proofs; as when a living animal is placed under the receiver of an air-pump, and the air is removed, the creature struggles, gasps, and expires. Drowned animals die solely from interruption to respiration, and even the suspended criminal does not cease to live, either because the neck is dislocated, or the circulation in the head is stopped by the compressing cord, although both are popular opinions. He dies because his breathing is interrupted, and the blood cannot undergo the necessary changes from the action of the air.

The necessity of a due supply of air is proved by the following painful, but highly interesting narratives.

The Viceroy of Bengal, having, in the month of May 1756, made the English garrison at Calcutta prisoners, he inhumanly shut them up, to the number of 146 persons, in a place called the Black-hole prison, a cube of about 18 feet, and open only to the westward by two windows strongly barred with iron. In this horrible situation were 146 human beings stewed up, in a close sultry

night, under the climate of Bengal. A profuse perspiration quickly broke out on every individual, attended with an insatiable thirst, which became the more intolerable as the body was drained of its moisture. It was in vain that they stript off their clothes, or fanned themselves with their hats. A difficulty of breathing was next observed, and every one panted for breath.

In this dreadful situation the unfortunate prisoners made an application to have some of them removed to another place of confinement, but in vain; the tyrant, by whose order alone such a step could be taken, was asleep, and no one durst disturb his repose. Their despair now became outrageous. They endeavoured to force open the door, that they might rush on the swords of their guard, and even used abuse to provoke them to fire, but all their efforts were ineffectual.

The agonies of these wretched sufferers for want of air now became horrible, they could no longer endure the dreadfulness of their situation, and many fell down, and expired. We shall not torture the feelings of the reader by describing the scene that ensued. The unfortunate victims, notwithstanding they pressed towards the windows to gasp a little air, dropt fast on all sides; a pungent steam arose from the bodies of the living and the dead; and, dreadful to relate, when the tyrant

thought proper to throw open this infernal prison, only 23 out of 146 men were found alive: all the others were suffocated for want of air.

Another melancholy proof of the necessity of a due supply of air, may be drawn from the testimony of Dr. Trotter, delivered before a select committee of the house of commons in the year 1790.

In July 1783 the slave-ship, in which he was, arrived off the Gold Coast of Africa. "In the space of a week above 100 prime slaves, young, stout, and healthy, were purchased. The ship, however, could obtain only two-thirds of her complement. The slaves were confined below sixteen hours out of twenty-four, and were allowed no exercise when on deck. The rooms where they are confined, are from five to six feet high, imperfectly aired by gratings above, and small scuttles in the side of the ship, which of course can be of little use at sea. The gratings are also half covered when it blows hard, to keep out the salt spray." The temperature of these rooms was often above 96 of Fahrenheit's scale. In the evidence, of which this is an abstract, Dr. Trotter affirms, "he could never breathe there, unless under the hatchways." In such circumstances the sufferings of these poor fellow-creatures must have been dreadful. "I have often," says Dr. Trotter, "observed the

slaves drawing their breath with all the laborious and anxious efforts for life, which are observed in expiring animals, subjected by experiment to foul air, or in the exhausted receiver of an air-pump. I have seen them, when the tarpawlings have been inadvertently thrown over the gratings, attempting to heave them up, crying out, in their own language, we are suffocated. Many have I seen dead, who the night before have shewn no signs of the smallest indisposition; some also in a dying state, and if not brought up quickly upon the deck, irrecoverably lost."

Hence, before the arrival of this vessel at Antigua, out of 650 slaves more than 50 had died, and above 300 were tainted with the sea scurvy.

Why the Air must be renewed.

The air of a crowded theatre has been examined, and it is found to be materially different in its properties from the external atmosphere. It contains much more fixed air than before the performance commenced. This air is heavy, and sinks to the bottom; the azotic part, which has now lost the oxygen with which it was intimately combined, being light, rises to the top of the house; while the middle portion is of the greatest purity. Besides these changes, a moist vapour is

diffused through the whole; this in cold weather is condensed, and thus rendered visible.

Of the various aëriform fluids we are acquainted with, few are injurious to animals, although none can be substituted for oxygen; but some are highly deleterious, and particularly carbonic acid. Hence it is that we suffer so much distress in crowded rooms, which in some circumstances is followed by the worst consequences. In mines, in long closed wells, and small rooms heated by brasiers of charcoal, this air is collected in such quantity as to produce every degree of mischief, from giddiness to insensibility, and from stupor to death. On this account, if an animal is confined under a glass vessel filled with air, it dies before all the oxygen is separated from it, because the carbonic acid acts as a poison. If, however, the apparatus is so contrived, as to absorb the carbonic acid as fast as it is produced, the animal can live till the air is deprived of all its oxygen.

The opposite effects from breathing a pure air illustrate the function of respiration very strikingly. Hence the refreshment we derive when we inhale a draught of fresh air on leaving a crowded apartment; hence the quick dissipation of the languor and anxiety which before oppressed us; the almost instantaneous recruiting of our spirits and our strength.

If we respire an air of still higher purity, such as we can produce by artificial means, when we separate the oxygenous part of the atmosphere from its other ingredients, these effects are felt in a greatly superior degree. The pulse is quickened, and beats with stronger vibration, the complexion is heightened, the spirits are more gay, and the whole frame is invigorated.

We have now seen that the following changes are produced in the air by respiration, the oxygen is removed, and the carbonic acid is increased in quantity.

It has been estimated that about 2lbs. 8oz. of oxygen are consumed by a man in 24 hours; and that in the same time about 3lbs. of carbonic acid are generated.

The oxygen which has disappeared is more than was necessary to constitute the carbonic acid, and whether the remainder is absorbed by the blood and applied to some yet unascertained purposes during its circulation; or whether it combines with some of the hydrogen contained in the blood, and forms the aqueous vapor we expire, are problems not at present solved. Indeed it is a subject of peculiar difficulty to investigate satisfactorily, because the surfaces of the air-cells are always moistened with a liquid, which will be carried off by every expiration.

Effects of the Air on the Blood in the Lungs.

We have before shewn that the lungs were two spongy bodies, which occupy the cavities of the chest; that they are composed of blood and air-vessels united together by cellular membrane; that the blood-vessels are the great pulmonary artery going out from the right side of the heart, and splitting into innumerable branches throughout both lungs, and the veins which commence from the extremities of those branches, and run back to the heart again; that the air-vessels commence by that great tube called the windpipe at the back part of the mouth and nose, which running down into the chest, divides into two lesser tubes, one going to each lung, where, after branching out in the manner of blood-vessels, they terminate in cells, communicating with each other; and lastly, that the air is constantly passing to and from those cells, while all the blood of the body, as constantly circulates through the vessels of the lungs, to receive certain properties from the air.

The blood has a different appearance in the arteries from that which it assumes in the veins. In the last case it is of a deep red, or dull purple tint, while that from an artery is of a bright scarlet. That this change is effected in the lungs, was proved by the following cruel experiment.

The chest of a living dog was opened, the lungs and heart were exposed to view. The blood which was driven from the right side of the heart into the great artery of the lungs, appeared of a dark venous complexion.

But, this blood, on its return from the lungs to the left side of the heart, lost its dark appearance, and assumed a bright vermilion colour.

It was soon found necessary to inflate the lungs by artificial means.

If at any time this was intermitted, the blood returning from the lungs to the left side of the heart, did not take on the bright vermilion colour, but appeared dark as before it had been sent to the lungs; a diminution of the pulsations of the heart and arteries took place, and in a little time all their actions ceased.

But if at this time the lungs were made by the inflation of common air alternately to collapse and dilate, the blood coming from the lungs regained its former bright colour, and the action of the heart and arteries was excited anew.

Again, if blood be drawn from a vein, it will at first appear of a dark colour as was before remarked, but on being exposed to the air, it will become red on that surface which is in contact with it; and if shaken in a phial with air, the whole will become red, and the oxygenous portion of the

air will be diminished, while some carbonic acid is formed, as in respiration; but in vacuo, however shaken, there will be no redness.

Thus we find that the blood in passing through the lungs, changes its colour, and at the same instant parts with a quantity of carbonaceous matter in combination with the oxygen it has obtained from the air. We shall afterwards point out other important changes produced in it by respiration.

The Blood derives from the Air the Means of supporting Life, and the Heat of the Animal.

We have already shewn the dependence of the life of man upon the air he breathes, also the part of the atmospheric air which is essential to his existence, and that the office of the lungs is to enable the blood to absorb constantly this portion of the air, that it may be diffused throughout the whole system; we shall now view the great effects which the vital portion of the atmospheric air (the part which is absorbed by the blood), has upon the animal œconomy; and first that of enduing the blood, and afterwards the rest of the body, with vitality.

The intimate connexion which subsists betwixt the air and animal life, must have been known from the earliest ages; for it is illustrated by numberless facts, and those of perpetual recurrence. Thus with the new-born infant, the first

thing we do is to infuse into his nostrils "the breath of life." For until the lungs are expanded, and the venous or purple blood is changed by the air into arterial or crimson in that organ, the heart does not contract, nor the arteries vibrate; and like a clock that is not wound up, though sound in all its parts, they remain entirely at rest. In the clock, if we but wind it up, the main-spring applying its powers, all the wheels are immediately put into motion, and it marks its hours and its minutes; so likewise in the animal machine, the blood in the lungs having imbibed the vital principle of the air, the heart acquires its actions, the brain its energy, the nerves their sensibility, and the other subordinate springs of life presently resume their respective functions.

The lady of a physician had a child still-born. All the common means were tried without effect. Recollecting he had a bladder of vital air, with which he was about to make an experiment, the doctor forced this air into the lungs of the infant, when the eddies of its little heart began to play, and the child was restored.

In that experiment which was before described, as shewing the changes produced in the blood by respiration, a sort of artificial breathing was effected, by attaching a pair of bellows to the lungs of the animal. If the lungs were not inflated for

some time, the blood returned to the left side of the heart unchanged in colour; it was still venous, and the action of the heart languished till it even ceased to contract; but its motions were revived with new energy when the lungs were filled with fresh air, for the blood was then rendered arterial, and had acquired its due stimulating properties. The circulation was restored, and life continued.

The vast number of cells into which the lungs are divided, the whole arterial and venal system ramifying on the surface of those cells, and of course the whole of the blood passing through them in every circulation, together with the loss of life where breathing is interrupted even for a short time, shew the influence of the air upon the blood for the purposes of life. The blood continues it by imparting this same vital principle to every part of the body. Hence it is to the atmosphere (or rather to that particular part of it which is called vital or oxygene-air) that we are indebted for that vitality which is communicated to the blood, and which animates our bodies, and is the immediate bond of union betwixt our immaterial soul and this visible world. In this state we may be compared to small pieces of feather placed upon an electrical machine, which while the handle is turned, dance upon the conductor, but the moment of cessation, they all cease to move, and fall down.

ON

ANIMAL HEAT.

We have before had occasion to notice the analogy between combustion and respiration. Both processes arise from a change of state which the oxygen of the atmosphere experiences. It enters into new combinations, and while they are forming it parts with its heat. In breathing it is absorbed by the blood, and slowly unites with some of its elements. In combustion the change of state is far more rapid, an intenser heat is developed, and we see a light of more or less brightness. To this difference of rapidity with which the combination is effected, is the variety of appearances in the two phenomena principally owing; but it will be curious to trace their resemblances.

If an animal be placed in an exhausted receiver of an air-pump, it quickly expires; in similar circumstances a burning lamp goes out. If an animal be not supplied with fresh air it dies, and its heat is extinguished, so it is with the lamp. The air breathed by animals is diminished in quantity by the absorption of its oxygen, so it is by the burning of the lamp, and in both cases fixed air is produced. A certain quantity of air supports an animal for a certain time, but no longer; so it will

keep up the flame of the lamp, for a certain time only. The air in which a lamp has burnt out destroys animal life; so the air that the animal has breathed, puts out the lamp. Fixed, azotic, and inflammable airs, destroy animals; so likewise do they extinguish the lamp.

A living animal, and a burning lamp, therefore, exactly agree in requiring the same kind of air to support them, and in producing the same effects upon the air to which they are exposed. But they do not resemble each other only in producing heat, and requiring the same kind of air; for if an animal has not fresh supplies of food, as well as air, after a certain time it dies, and becomes cold; just in the same manner as the lamp dies out, if not duly supplied with oil. As oil affords the principles attractive of oxygen to the lamp, namely, hydrogen, and carbon, of which it is constituted; so the food of animals supports the generation of heat, by supplying to the animal body similar principles, which are attractive of oxygen; accordingly we find that all substances which afford proper nourishment contain principles that readily combine with oxygen, namely, hydrogen, which, in combination with oxygen, forms water; and carbon, or charcoal, which, when united also with oxygen, forms fixed air. We have found that both these substances are produced in respiration,

as well as in combustion. This connection between the heat of animals and their supply of food, is illustrated by the circumstances of those which are torpid during the winter months. These, if they lay by no internal store, are amply provided by an accumulation of fat in their own bodies. This, while it confines their heat, is gradually absorbed, and keeps up a gentle warmth, barely necessary for the existence of the creature. When he is roused by the recurrence of spring, he appears from his dormitory, weak, and extremely emaciated, till a fresh supply of nourishment reaccumulates an excess of fat for a future winter.

How Life depends upon a due Quantity of Animal Heat.

In the last article it was shewn that vital heat arose from the decomposition of oxygen air in the blood. In this it will appear, how life depends on a certain degree of heat in the body.

In the chick contained within an egg there are no powers capable of generating heat. Therefore until the chick receives heat from the mother, it remains in a torpid and inactive state. The principles of life are then called into action. A gradual extension of the parts commences. During the time of incubation, the living principle every day increases in quantity and power with the per-

fection of the animal, and the capacity of its organs for performing its functions, and generating heat, which last does not happen till the time of its exclusion from the shell: after which, the chick does not depend entirely on the mother for the production of that heat which must always acccompany and support the functions of life. When, by respiration, the first action after birth, oxygen air is absorbed by the blood, the motion of the heart, the circulation, and other operations, are carried on with greater vigour than formerly, and the food being separated into principles attractive of oxygen, the chick is capable, in a great measure, of generating a degree of heat equal to that of the parent. At first the mother, as if conscious of the tender state of her offspring, and of the impossibility of their being kept sufficiently warm by their own powers, gathers them under her wings to cherish that vital warmth, which she appears to judge them incapable of creating, and without which they would necessarily perish. In the same way, if, during incubation, the hen leaves her nest so long as to cool the eggs a few degrees; from that period the powers of life are proportionably diminished, and a stop is put to the growth of the chick; both of which, if the eggs have not been cooled too far, are recoverable on the return of the hen, or of that genial heat they receive from her body. The

mother is so solicitous to preserve this heat, that she seldom leaves her nest above five or six minutes in the day, to take a slender repast; and when she discovers the motion of the chickens in the eggs, she then sits so close, that even the sight of food, though ever so much pressed by hunger, can scarcely prevail with her to stir from the eggs for three or four days, or until they are completely hatched. But if she abandons her nest altogether, or is killed by accident, then, as the eggs cool, the powers of life gradually decline, till they are at last totally abolished by the death of the chickens.

Though the functions of life, in this instance, are soon destroyed or suspended for want of a due quantity of animal heat, yet in some creatures, under these circumstances, the vital principle still remains entire. Thus flies, when the cold comes in, appear as if deprived of sense, and in proportion to the degree of cold, the moving mechanism is retarded. But if the weather be intensely cold, they then "sleep the sleep of death." Hence the reason why we see toads burrowing, frogs living under large stones, snails seeking shelter in the hollows of trees, and fishes having recourse to deep waters; the heat of all these places being generally above the freezing point, even in our frosts, which are, however, sometimes so severe, as to kill many whose habitations are not well chosen.

Temperature of the Human Body.

The heat of every living body generally exceeds that of the surrounding atmosphere, and it is observable that it is more or less high in proportion as the function of respiration is more or less perfect in the animal. Birds have the most extensive organs for breathing, and are of the highest heat; quadrupeds are a few degrees cooler; while fishes and reptiles are very little warmer than the medium in which they live. Even in torpid animals it is constantly higher by some degrees than in the air around them, and a thermometer being put under the tongue of man in all countries and seasons rises to 97. This proves that a constant generation of heat takes place in the body, and that a portion of this heat is as constantly escaping from the system. The balance between these two actions constitutes the degree of heat which the animal enjoys.

To regulate this degree of heat various means are employed: hence we see why nature varies the cloathing of animals in different climates; in the warm ones she covers them with short, smooth, coats, which lie close to the skin; while in the northern regions their covering consists of a rarer substance, as fur, wool, &c. all which prevent the escape of too great a quantity of animal heat.

Hence also the great use of feathers to birds; as these creatures are often exposed in the higher regions to a very cold medium, their natural heat would pass off much too quickly, if they were not covered with a substance which conducts heat very slowly: feathers are well known to have this property; and in those birds that live in water, which withdraws heat more quickly than air, their covering is a much slower conductor of heat than common feathers. The down upon the breast and under the belly of such birds as in cold climates, live mostly in the water, is, perhaps, the slowest conductor of heat in nature, such is the eider down: and to keep this rare substance constantly dry so as to resist the effect of the water, these aquatic birds spread a sufficient quantity of a peculiar oil, with which they are furnished by an organ for that purpose, over their outermost feathers, and thus prevent the contact of the water.

It is to regulate the standard of animal heat, so that it may be agreeable and healthy, that the inhabitants of all countries in which the temperature of the atmosphere is below that of the human body, make use of apparel; and this being thicker or thinner in proportion to the respective differences of seasons or climates, is founded on the same principle "to prevent too great an escape of heat from the body, which would induce the unpleasant and injurious sensations of cold."

On the other hand, if the heat be so great as to incommode, nature has recourse to the refrigerating process of perspiration, when by the formation of vapour, a greater quantity of heat is carried off than could be merely by the air. This is the reason why the sensible perspiration is so much greater in hot than in cold weather. Fanning relieves by favouring the escape of heat from the body: for when the surface is loaded with heat, and the air, which is in immediate contact with it, has already taken up so much that it is either unable to carry off any more, or performs this office so slowly, as to be unequal to the removal of the quantity which is constantly arriving at the surface, by driving away such air, and permitting other colder air to approach, which not being so loaded is able to carry off the heat more quickly, the skin must in consequence feel cooled.

Moist air is, likewise, a better conductor of heat than when dry, because water, though of the same temperature with air, is known to carry it off more quickly than air will do. And this is the reason why in moist and windy weather our sensations of cold are greater than when the air is still and dry, though the thermometer should, in both cases, stand at the same point.

OF

SUSPENDED ANIMATION.

From the view we have taken of the atmospheric air, and the absolute dependence of animal life upon it, there will be no difficulty in explaining to the reader, " how the powers of life seem to vanish, and death to set in," when persons are placed in those situations where they cannot breathe; nor of the utility and reasonableness of the means which ought to be used for the recovery of such individuals as may unfortunately happen to be in this condition.

We have already shewn that an animal placed in the glass receiver of an air-pump, where the air can be exhausted, will, after a certain time, expire. And in the experiment on a dog, it was seen that when Dr. Goodwin ceased to blow air into the lungs, the heart and arteries no longer pulsated, and life appeared to decline; but that when the doctor again inflated the lungs with fresh air, the vital organs resumed their functions, and the animal rapidly recovered. These facts serve to explain the cause of death from drowning, &c. and also the recovery of life, where the person has been only so long immersed, as that the vital principle is suspended, but not extinct.

Some have supposed that death was caused in hanging by apoplexy; and in drowning by the introduction of water through the windpipe into the lungs; but late experiments shew that these are not the case.

A dog was suspended by the neck with a cord; an opening having been previously made in the wind-pipe below the cord, so as to admit air into the lungs. In this state he was allowed to hang three quarters of an hour, during which time the circulation and breathing went on without being much interrupted by the experiments. The cord being now shifted below the opening into the wind-pipe, so as to interrupt the ingress of air into the lungs, the animal was completely dead in a few minutes: a proof that the air being intercepted in its passage, and not a mere accumulation of blood in the brain, was the immediate cause of death.

In drowning it is known that but a very little if any water can find its way into the lungs. If an artificial dropsy of the chest be produced by injecting two ounces of water into the lungs, through the wind-pipe of a healthy animal, it immediately causes oppression, and difficulty of breathing, but no fatal suspension of life ensues. The water is absorbed gradually, and the symptoms soon disappear. The case is very different

in drowning, since in this a few minutes submersion is sufficient to destroy the life of the animal, even whether water enter the wind-pipe or not, for in most cases some is found in the lungs after death. This is decisively proved by the experiments of Dr. Goodwin. He placed animals in quicksilver, and in ink, and so little of this weighty metal or coloured fluid was found in the lungs, as left no doubt of its not being the cause of drowning. In one experiment after expiration the animal was drowned in ink, and no fluid whatever was found in the lungs. Hence we see how superfluous the common custom is, of suspending a drowned person by the heels to discharge the supposed contents off the lungs.

Hanging and drowning then occasion death by preventing * the access of air to the lungs, and

* Though apoplexy is not necessary to produce death in hanging, yet it sometimes occurs as an accidental circumstance. And I am just informed by Mr. White, whose publications on the veterinary art have rendered it great services, and do him much credit, that in cases where horses have been strangled by their collars becoming entangled, he has, in more than one instance, found on dissection, that either the right auricle of the heart, or the great vein called *cava*, a little before it entered the heart, was burst; and this he supposes to have taken place from the too great pressure of the blood on these parts, owing to its passage being obstructed in the lungs.

the expulsion of the effete of fixed airs. We shall confine ourselves to the consideration of drowning.

Of Drowning.

When an animal is immersed in water, his pulse becomes weak and frequent; he feels an anxiety about his breast, and struggles to relieve it. In these struggles, he rises towards the surface of the water, and throws out a quantity of air from the lungs. After this his anxiety increases, his pulse becomes weaker; the struggles are renewed with more violence; he rises towards the surface again; throws out more air from his lungs, and makes several efforts to inspire; and in some of these efforts a quantity of water commonly passes into his mouth; his skin then becomes blue, particularly about the face and lips; his pulse gradually ceases; and he falls down without sensation, and without motion.

This description of drowning applies very nearly to the effects occasioned by some supposed noxious airs, which merely act by preventing the access of the air of the atmosphere.

Other airs there are of a very poisonous nature. Among the most powerful is fixed air, as it is given out by burning charcoal, in long closed wells, in fermenting vessels, and in some natural caverns. The description applies to a great variety of circumstan-

ces in which the access of air to the lungs of animals is prevented, as by shutting them up in a glass receiver, or closing the wind-pipe with a cord, so as to interrupt the passage. In all these cases a want of air induces suffocation: the vital functions cease: life becomes suspended, and death to all appearance has taken place.

This absolutely will be the case if the animal is allowed to remain long without the means of recovery being had recourse to: instead of a mere suspension of the powers of life, they will become extinct, and the unfortunate victim must be irrecoverably lost. But if the proper means be used in time, before the vital spark is totally extinguished; like gently fanning the ignited wick, the flame of life will be rekindled, and the apparent corpse restored.

Drowning is defined by the celebrated John Hunter, to be "a stop put to the actions of life in the animal, but without any irreparable injury done to any vital part; which action, if not restored by art in a certain time, is irrecoverably lost."

The cessation of motion from drowning, arises from the interruption of respiration, and the immediate effects which this has upon the other vital motions of the animal; for the motion of the heart then ceases. It is not roused to contract by

its proper stimulus; the blood is no longer arterial, and is not endued with those properties from the air on which its stimulating qualities depend. This cessation of the heart's action is a second or consequent change, and most probably the restoration of breathing is all that is necessary to renew the heart's motion. If a sufficiency of life still exists to produce that effect, we may hope that every other part will be put into action the very instant in which that of the heart takes place; their actions depending so much upon it.

That in recovering persons drowned, the principal object is to throw air into the lungs, is shewn by what happens in the birth of children, when too long a time has elapsed after the interruption of that life which is peculiar to the fœtus. They then lose altogether the disposition for new life, and in such cases there being a total suspension of the actions of life, the infant remains, to all appearance, dead, and would in fact die, if air was not forced into its lungs, by which means the action of the heart is established. Respiration is the first of that chain of functions on which the phenomena of life depend.

This is farther illustrated by Dr. Goodwin's experiment on the living dog.*

From the effects which we have seen the air has,

* See page 197.

1st, In giving a florid colour to the blood,

2nd, In generating animal heat,

We learn, why in suspended respiration, when the lungs are not expanded, and the blood is not changed, the heart ceases to contract, the arteries to vibrate; and finally, why the animal machine, though sound and entire in all its parts, yet on a sudden, like a clock whose pendulum is stopped, remains entirely at rest. For as in the latter, if we move but the pendulum, the wheels are immediately put into motion, and the clock again correctly marks its hours and minutes as before: so likewise in the animal machine, (such is the harmonious consent of its parts) if motion can but be renewed in one of the principal organs, it is directly communicated to that which succeeds it in office, and from thence to all.

Thus, if the lungs expand, and the blood imbibes the vital part of the air, the heart recovers its action, the brain its energy, the nerves their sensibility; and the subordinate springs of life presently resume their respective movements.

From the privation of air in drowning, we can now explain, why the blood grows dark, the lips and countenance livid, and why the body loses its native heat. By renewing respiration, the circulation is renewed, and the blood having regained

its florid colour, all these symptoms soon disappear.

The primary object, therefore, in the suspension of vital action, is to institute artificial respiration till the natural breathing can be re-established, to accomplish which, the following are the most efficient and approved means.

Of the Means for recovering drowned Persons.

An animal apparently drowned, should be considered as not dead; but that only a suspension of the actions of life has taken place. The situation of such a person might be compared to that of one in a trance. In both, the actions of life are suspended, without the powers of action being destroyed. But as in all cases of apparent death, time presses, so the urgency of the case demands uncommon expedition. In this critical situation, the vital spark, like the last glimmering of a taper, at each succeeding minute grows more and more feeble, till the instant it expires.

Expedition being used in preparing for the recovery, the moment the object arrives, all spectators should be excluded the room, except those that are absolutely necessary, and which, perhaps, never need to exceed seven in all, including the medical assistants. A greater number will not

only embarrass the operation, but render the air impure by their respiration, and the contaminated air of a crowded room, in cases apparently favourable, may defeat all hopes of success, as has been seen with regret in more than one instance. If the weather will permit, the windows should be kept open, and the temperature be regulated between 56 and 64 of Fahrenheit's thermometer. If the season be perfectly serene, the body may be placed in the open air to receive the genial warmth of the solar rays, while the other necessary means of recovery are pursued. The body, if wet, must be immediately well dried, to prevent the chilling effects of evaporation, and then be wrapped in warm blankets, or the warm clothes taken from some of the spectators, unless the cooling process should be first necessary, in consequence of the object being in a half frozen state. For in that case the body ought to be rubbed with snow, or flannel wrung out of cold water or vinegar, before any degree of artificial warmth can be safely applied.

Having prepared a bed or mattrass, on a table of a proper height, the subject is to be placed thereon, with the head elevated by two pillows; when the different parts of the process may be conducted in the following order:

1st. Let the lungs be immediately inflated by

means of the proper instruments. The most useful one is at the same time very simple. It consists merely of a pair of double bellows with a double nozzle branching out at an angle that will admit of its introduction into the nostrils, and it is used in the mode immediately to be described. When no medical assistant can be had in time, this operation may be tolerably performed by any expert person who may be present, by only inserting the pipe of a common pair of bellows into one nostril, while the mouth and opposite nostril are closed by an assistant, and the wind-pipe gently pressed back. Then by forcing air into the lungs, and alternately expelling it by pressing the chest, respiration may be imitated. Or, upon an emergency, air may be blown into the lungs through a tobacco-pipe, a quill, or even a card folded into the form of a tube. Not only this but the rest of the process might certainly be performed without much difficulty by any expert persons, were they properly instructed; since it appears that, in Holland, more than half the recoveries of the drowned are brought about by persons not medically educated.

The reader will here perceive that the intent of inflating the lungs, is to excite the heart and blood vessels to renew the circulation; when the other actions of life would soon follow. And the more

effectually to procure this grand effect, the more pure the air which is injected the better: for which reason atmospheric air is preferable to that which has been respired; but vital air to both.

2dly. Particular stimuli may next be applied to the organs of sense to rouse them, as a strong light to the eye, and pungent substances to the nose, such as common smelling salts, or the concentrated aromatic vinegar.

3dly. These operations being carried on for five minutes, good wine, or some other cordial, should be conveyed into the stomach.

4thly. Immediately after this a stimulating glister may be also administered, consisting of warm wine and water. The cordial, and enema, may if necessary be repeated near the close of the process.

5thly. These internal stimulants being given to provoke the action of the heart, bladders of tepid water should at the same time be applied to the region of the stomach, and to the extremities.

6thly. The legs and arms must be now diligently rubbed with the warm hand, or with flannel, or a hare-skin. The friction must be gradually extended to the thighs, abdomen, and chest.

7thly. At that critical period when sneezing, slight twichings, or gasping, mark the first dawn of returning life, instead of increasing, it will be

prudent to moderate the stimulating powers, lest the vital action, still faint, should be overpowered, and irrecoverably extinguished.

8thly. The process here recommended should be continued the full space of three hours, with very few intermissions, unless the vital functions should be restored sooner. If, at the end of that period, the unfavourable symptoms, instead of diminishing, should increase, the case may be considered as utterly hopeless, and therefore the process may be discontinued. Still, however, before quitting the room, it may not be improper to order a strong blister to be applied to the region of the heart, and warm sinapisms to the feet, first sprinkled with the volatile alkaline spirit.

9thly. When the natural respiration and the power of swallowing are restored, the patient should be put into a bed moderately warm, with his head properly raised, and his feet wrapped in warm flannel. Warm whey, and other diluents, may now be administered, to encourage a gentle perspiration. But he ought by no means to be left alone, till he has perfectly recovered his senses: some persons having relapsed, and afterwards perished, from being deserted too soon, even after the functions were apparently restored.

10thly. Should feverish symptoms ensue, ac-

companied with a sense of heaviness, or dull pain in the head or chest (as frequently happens in consequence of the severe discipline so lately undergone), moderate bleeding, together with mild laxatives, and cool regimen, will generally afford the desired relief.

In the above description of the mode to be pursued for the recovery of drowned persons, the object has been to enumerate the means of most importance, and at the same time of the easiest application, under the idea that a medical man is not always upon the spot. No time, however, should be lost in sending for one, and the above modes may be employed previous to his appearance, particularly the artificial breathing, the warm frictions and bladders, the use of stimulants to the nostrils, and to the intestines. More powerful agents may be had recourse to under judicious directions, and when the simpler operations have been duly tried. Such is the use of electricity. It is applied in the following mode:

The machine being prepared, and the lungs expanded, let one discharging rod be placed just below the right breast, and the other above the short ribs of the left; the electrometer being moved a quarter of an inch from the jar. Let the electrical current be passed directly through the heart to excite

it. The shock being given, let the lungs be expanded by making an expiration with the double bellows, or by suffering air to escape through the mouth, while gentle pressure is made on the chest. The moment this is accomplished, let the lungs be again expanded, and the shock repeated; varying its direction, its power and its frequency, as circumstances may point out. It is important to notice that all the agents, when first applied, should be of a weak force, and their power should be gradually increased. If this is not duly attended to, the feeble irritability in the system may be destroyed, particularly when stimulants so powerful as electricity are made use of.

Our hopes are often baffled, even when appearances seem to justify their indulgence; we can often excite the muscles to contract, locally at least, and yet not reanimate the subject. But we should not despair or discontinue our exertions, so long as the faintest traces of this power can be perceived. Hopes have been entertained that the galvanic influence will greatly avail in such cases. How far they will be realised remains yet to be ascertained.

It is neverthelss obvious, that like the electrical apparatus, it is rarely at hand to be employed in so urgent a moment, and to be duly applied it re-

quires such a preparation of the nerves and muscles of the subject, as is in itself incompatible with the continuance of life. It must be confessed however that its powers of exciting muscular contractions, are singularly great, and that simpler modes of application may be discovered.

OF

FOOD.

HAVING traced our relationship with the air we breathe, and the astonishing effects which this fluid has upon the animal œconomy, through the medium of the blood; we shall now come to shew how the blood, which is incessantly diminishing its quantity, by rebuilding the wasted parts of the frame, is itself replenished by a constant accession of fresh and wholesome supplies, that there may be, at all times, a sufficient quantity of this nutritive and healing fluid circulating throughout the whole body, for the purposes of its growth and nourishment. These supplies are abundantly furnished in the animal and vegetable kingdoms, and the Creator has given to man hands to gather and prepare them for the mouth, and also a set of organs whose office it is to assimilate them with the circulating blood. We shall first view those organs anatomically, and afterwards explain how they accomplish their various functions.

OF THE

ORGANS OF DIGESTION.

THESE occupy, for the most part, the great cavity of the abdomen, and are, principally, the stomach, the intestines, liver, spleen, and pancreas.

Of the Stomach.

The stomach may be compared to a large bag or pouch for receiving the food; it is situated a little below the diaphragm, or that muscle within the body which divides the cavity of the chest from that of the abdomen, and has two muscular tubes or pipes opening into it: one of these leading from the back part of the mouth, down through the chest, into the stomach, opens into this organ at the left side. This tube is called the œsophagus, it runs between the air-tube and the spine, and conveys the food from the mouth into the stomach. From the right orifice of the stomach arises the other tube, which is intended to convey away the food after a certain time: this tube constitutes the intestinal canal, and shall be more fully explained hereafter. The stomach is a highly irritable and sensible organ, having numerous muscular fibres entering into its composition, and being plentifully supplied with nerves. On its outside it is covered

by a membrane called peritoneum, because it lines the abdomen, and contains the different digestive organs within its duplicature: this membrane not only sustains them in their proper situations, but also affords a fine mucous fluid for keeping their surfaces constantly moist, and thereby preventing the injuries which would otherwise arise from friction. From the internal surface of the stomach there is a fluid constantly secreting, called the gastric juice, and which has the peculiar properties of dissolving and attenuating the food before it passes into the intestines.

Of the Intestines.

The intestines are a long membranous and muscular canal, which arises from the right orifice of the stomach, and is generally five or six times the length of the body, forming many circumvolutions in the cavity of the abdomen, which it traverses from right to left, and again from left to right. Their structure is not unlike that of the stomach, being composed partly of muscular and nervous fibres, and possessing a high degree of irritability, as may be seen by their worm-like motions, even out of the body after death, when pricked with a needle, or otherwise stimulated. Soon after the intestinal canal goes out from the stomach, an oblique opening may be perceived by which the

fluids from the pancreas and liver are poured into the intestine for the purpose of mixing with the food as it passes downwards: and that the descent of the aliment may not be too rapid, by which the body would be deprived of a supply of nutrition sufficient for life and health, the inner coat of the intestines is thrown into a number of plaits, that are admirably calculated to retard the progress of the food, till the whole of its nourishing properties are extracted and absorbed by the proper vessels. The whole internal surface of the intestines is kept constantly moist by the discharge of a mucous fluid, which favours the proper descent of the alimentary pulp, and helps to secure these organs from injury. The intestines and stomach have a structure very nearly similar to each other; so that the description of one applies to the other with sufficient accuracy for our purposes.

They have three coats; the internal one has been described as secreting a defending mucus. Here open into the cavity of the intestines those small absorbing vessels which take up the nutritive particles; they are called lacteals. They arise from the upper intestines principally. Next to this is the muscular coat; its fibres run in two directions; the one set embraces the intestines as small circular bands, or nearly so; and their purpose is obvi-

ously to shorten by their contractions the diameter of the intestine. Other fibres take a longitudinal course, and shorten it in the direction of its length. The combined action of these fibres produces the vermicular motions, and propels the contents of the intestines downwards; as the parts are stimulated by the distension of the food. The last coat is the peritonial, or investing one; it is a common covering to all the contents of the abdomen; which it at the same time lines. In order to cover the intestines it rises double from the spine, to which it is attached. It passes some distance before it reaches the intestines. These it embraces and slings in its fold, as an injured arm is slung from the shoulder. Between the spine and the intestines it is seen like a thin and transparent membrane, allowing a sufficient motion to their different convolutions, without permitting them to become confused and entangled.

This is the mesentery, which is thus found to be a double membrane including between its laminæ arteries and veins, nerves and lacteals, branching with exquisite minuteness and delicacy.

Of the Liver.

This is the largest gland in the body, of a dusky red colour, immediately situated under the vaulted cavity of the diaphragm, chiefly at the right

side, but having the thin edge of its left lobe laid over the right side of the stomach. Anteriorly it is convex, posteriorly it is concave; very thick in its superior part, and thin in its inferior. The upper side adheres to the diaphragm, and is fixed to this and to the breast-bone by a broad suspending ligament. It is also tied to the navel by a ligamentous band, which had formerly been the vein by which the fœtus received nourishment from the mother, but now degenerated into a ligament.

The liver is intended to secrete a dark-coloured fluid, called bile, and for this purpose it is supplied with a large quantity of blood. Mostly all the veins of the other viscera of the abdomen, instead of returning their blood to the heart, agreeable to the general laws of circulation, by the great returning veins, run forward towards the liver, where they unite in one large trunk, called vena porta, and which soon after enters this gland, and is ramified throughout its substance. Here this great vein performs the office both of an artery and a vein, for like the latter it returns the blood from the extremities of arteries, while as the former, and by a singular exception, it accomplishes secretion. Besides this vena porta which furnishes the materials for the secretion of bile, the liver has an artery of large size for the purposes of

nutrition to the organ itself; which it would seem could not be effected by the venous blood of the vena porta.

The bile, after being separated from the mass of blood in the liver, is conveyed by very minute excretory ducts into larger ones, which also convey it into one great duct or channel, and which, as we before observed, opens into the intestines not far from the stomach. There is attached to the lower part of the liver a little membranous bag shaped like a pear, and which, as a small reservoir, contains a portion of the bile secreted in the liver: its neck is continued in the form of a canal, running to unite with that of the liver, when both enter the intestine, and pour in their contents by a common opening. With respect to the precise use of the bile physiologists are not determined; it would seem to perform some important part in the œconomy, and especially in the conversion of food into chyle, since that fluid is not separated until the pulpy contents of the stomach have been mixed with bile and the pancreatic juice. It certainly stimulates the intestines to act, for when the entrance of bile into the intestines is prevented by gall stones or any other obstructing cause, the bowels are costive: we know too that many of our diseases, particularly those we experience in hot climates, arise from the derangements in the functions of this organ.

Of the Pancreas.

This also is a gland, and in structure very similar to the salivary glands: it is placed behind the bottom of the stomach, towards the first vertebra of the loins, with one end pointing towards the spleen, and its other extremity extending forwards. It is about eight inches in length, two or three broad, and one in thickness, has a yellowish colour, inclining to red, and secretes a fluid resembling the saliva, by a duct which enters the intestine, together with the biliary canal.

Of the Spleen.

The spleen is situated immediately under the diaphragm, above the left kidney, and between the stomach and ribs. In figure it resembles a depressed oval, near twice as long as broad, and almost twice as broad as thick; it is of a bluish colour, and of a soft and spongy texture; its use is unknown. So unimportant, however, is its function in the animal œconomy, that Cheselden asserts it may be taken from dogs without any marked inconvenience.

Of the Omentum or Cawl.

There is a broad, thin, and transparent membrane arising from the inferior border of the sto-

mach, and reaching down as far as the navel; it is every where double, consisting of two thinner membranes, which are joined together by cellular texture, and in the cells of which great quantities of fat are sometimes deposited. The secretion of this fat is performed in the most simple manner, like secretions in plants, there being no glandular apparatus here. The fat is distributed very unequally in this membrane, it being in some places quite thin and transparent, and in other places above an inch thick: the cawl of calves gives a very beautiful representation of this fact.

The use of the cawl is principally to interpose itself between the peritoneum, the intestines, and the stomach, to keep all these parts moist, warm, slippery, and to prevent their adhesion.

Plate 4.

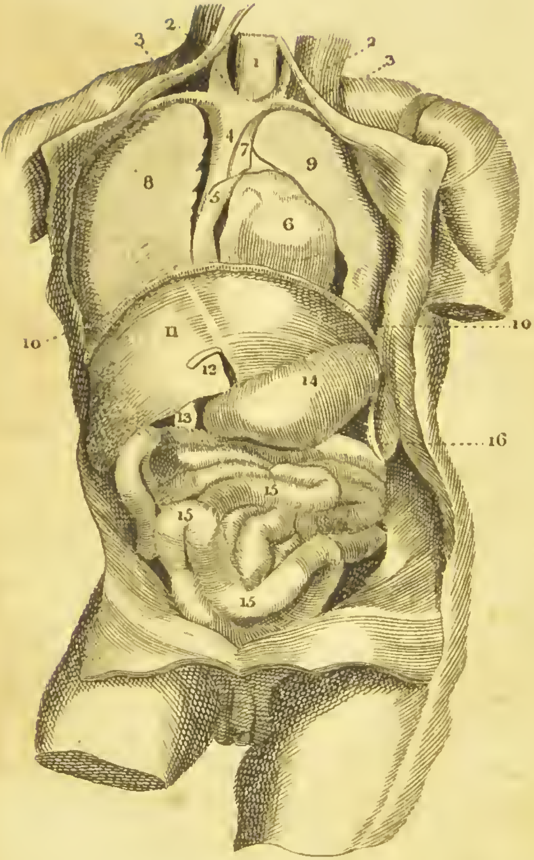


PLATE IV.

REPRESENTING THE VISCERA OF THE CHEST AND ABDOMEN.

1. The Trachea or Wind-pipe, before it divides to plunge into the substance of the Lungs.

2. The internal Jugular Vein returning the Blood from the inside of the Head. It joins the

3. Subclavian Vein, conveying the Blood which has circulated through the Arm: both form a common trunk, the

4. Descending Cava, which pours its contents into the

5. Right Auricle of the Heart, which receives also the Blood from the rest of the body by a large Venous Trunk, the Ascending Cava, which is not to be seen in this view.

6. The Right Ventricle. The Left Ventricle cannot be seen, as it is situated behind the parts now in view.

7. The Aorta, or Great Artery of the Body.

8. The Right Lobe of the Lungs, part of which is cut off to shew the great Blood-vessels: as is the Mediastinum, a Membranous Partition between the two Lobes of the Lungs, and dividing the Chest into two distinct cavities.

'. The Pericardium also is removed to shew the Heart more distinctly.

9. The Left Lobe of the Lungs.

10. The Diaphragm, or Great Muscle of Respiration, separating the Chest from the Abdomen, and upon which the Heart is seen to rest in its natural position. The Diaphragm is observed to be convex towards the Chest, and when we inspire this convexity is lessened, so that the Cavity of the Chest is lengthened; the Intestines are pushed down, and are protruded at the same time, because the Abdominal Muscles are then relaxed.

11. The Liver, which is suspended to the Diaphragm by a Ligament.

12. The Round Ligament, or what was the Umbilical Chord before birth; now rendered solid.

13. The Gall Bladder.

14. The Stomach pressed to the left side by the Liver.

15. The Small Intestines.

16. The Spleen.

Of Digestion.

The food having been sufficiently divided and attenuated in the mouth, by the action of the teeth and saliva, passes in the form of a pulp down through the œsophagus into the stomach. Still retaining its peculiar properties, the food now gently irritates the inner coat of this organ, and occasions a contraction of its two orifices: when being thus confined, it undergoes a constant agitation by means of the abdominal muscles, and of the diaphragm in breathing, by the motion of the muscular fibres of the stomach itself. By these continual movements every part of the food is exposed to the action of the gastric juice, which has the power (as water dissolves sugar) of farther dissolving and attenuating it, before it passes into the intestines. During this operation, mild and pleasing sensations are felt, owing to the gentle stimulus of the food against the sentient nerves of the stomach, and the encreased action which is produced in other parts by the presence of the new chyle. To the irritation of these nerves, by the gastric juice when the stomach is empty, is to be attributed those painful sensations of hunger, which are providently implanted to warn us that the stock of aliment is exhausted, and that there is a necessity for furnishing the system with a fresh supply.

Of Chylification.

The aliment having remained two or more hours in the stomach, during which time it is converted into a greyish pulp, called chyme, now passes out by the right orifice of the stomach into the intestinal canal. Here, as the digested food passes along the mouths of the ducts opening into the intestine from the liver and pancreas, it stimulates those ducts, (when by a law in the animal œconomy, which has given the highest sensibility to the nerves at the mouths of ducts, which, by a sympathetic communication, occasions their several glands either to secrete, or pour out a greater quantity of fluid) the chyme receives a full supply of bile and saliva; and it is further animalized by a mucus which mingles with it from innumerable exhalent arteries.

Thus diluted and mixed with juices, the chyme is in part changed in the small intestines into a milk-like fluid, called chyle, which is separated from the general mass, as it passes slowly along the intestinal tube, where this milky fluid is absorbed by numerous small vessels called lacteals, and the excrementitions remains are carried down the canal, to be eliminated.

Course of the Chyle to be mixed with the Blood.

The intestines, as we before observed, are generally five or six times the length of the body, and their internal surface is encreased by the plaiting of its internal coat; from a large proportion then of this great surface is the new formed chyle constantly absorbed by the lacteals, which are very minute, transparent vessels, arising in infinite number from the inner surface of the intestines, and forming a beautiful net-work as they pass onwards along the mesentery.

These vessels imbibe their chyle by their power of absorption, for this nutritious fluid being pressed against their mouths, in the various motions of the intestine, acts as a stimulus, when these delicate and highly irritable organs contract, and propel the fluid forwards beyond the first set of valves, which prevent its return. It would seem, however, that those orifices of the lacteals act by some other power besides capillary attraction, in as much as they select, as it were, the chyle from the rest of the chyme, and in fact will not take up some fluids that have been introduced into the intestines for the purpose of experiment. Thus the lacteals perform absorption in the same manner as do the lymphatics; nor is there any difference in the construction or functions of these vessels, but in the

colour of the fluids which they convey, and which is the cause of their being differently named.

From the intestines the lacteal vessels convey the chyle along the membrane called mesentery, and which we have described as extending from the intestine to the spine, for the purpose of sustaining the former in its proper place; here they may be easily seen in an animal killed two or three hours after feeding, for then they are distended with the new, white, chyle, which is carrying forwards into the circulation. Passing through this membrane, the lacteals run onwards to the thoracic duct, which we have described as being a common trunk or tube, lying principally in the chest, and which after receiving communicating branches from the whole absorbent system, opens into a vein not far from the heart. Into this duct, then, the lacteals empty their contents; which, soon after mixing with the lymph, conveyed to this tube from the various parts of the body, both fluids are carried along the thoracic duct to its opening into the vein, and there are poured together into the circulation Before it reaches the thoracic duct, the chyle enters one or more glands, where it undergoes some unknown change. These glands are attached to every part of the absorbent system, but more especially to the lacteals. They are very numerous at the root of the mesentery.

The chyle now mixing with the blood becomes soon assimilated; from the vein where it enters, it is carried directly to the right side of the heart, whence it is propelled into the lungs, to imbibe the oxygen or vital portion of the atmospheric air, and to part with some of its carbon; returning to the heart again, now formed into perfect blood, it is forced by the left side of this organ along the arterial tubes, to distribute life and health to every part of the animal machine.

Of the Kidneys.

These are two glandular bodies, situated in the loins, and contiguous to the two last short ribs, and lying close to the spine; the right under the liver, and the left under the spleen. Their shape and appearance is known to every one: they are enveloped in the lining membrane of the abdomen, in common with the other contents of this great cavity, and are retained in their position partly by this, and by the blood vessels which run between them and the great artery and vein of the body.

In each kidney, which in the adult is of rather a firm texture, three kinds of substance may be distinguished. The outer part is glandular, beyond this is tubular, and the inner part is papillary or membranous.

The kidneys are intended to drain the system of

its redundant water; for this purpose a considerable portion of the blood is constantly passing into each kidney by an arterial branch, which runs directly from the aorta or main artery of the body into this organ. Here, in the glandular part of the kidney, the blood undergoes a change, having its superfluous water, together with some saline bodies, separated, and is itself again returned to the circulation by means of a vein which goes to the great ascending vein of the body. The water being now strained from the blood is conveyed by an infinite number of small tubes, constituting the second substance of the kidney, out of its glandular part. These tubes, as they approach the inner substance of the kidney, gradually unite together; and thus forming larger canals, at length terminate in ten or twelve little protuberances, called papillæ, the orifices of which may be seen without the assistance of glasses. These papillæ open into a small cavity or reservoir, called the pelvis of the kidney, and formed by a distinct membranous bag which embraces the papillæ. The water being conveyed by the different tubes into the reservoirs of the kidneys, is farther conducted by two large membranous canals, each about the size of a common writing-pen, and which go out from the hollow sides of the kidneys. These canals open into the back and under part

of the bladder, whither they convey the redundant water of the system, and where, as in a great reservoir, it remains till such quantity be collected as is sufficient to induce irritation, when contraction of this sensible organ takes place, and the contained fluid is necessarily expelled.

The bladder is a hollow, membranous, and muscular organ, of an oblong form, situated at the bottom of the abdomen, immediately above the ossa pubis, or share-bones.

It is lined by a membrane which is defended by a mucus secreted from its inner surface. Next to this is its muscular coat, which is formed of fibres running in various directions, to contract it when filled, and to empty it completely. The outlet of the bladder is called its neck. Here the muscular structure is more obvious, and by the action of its fibres, which embrace the organ, the passage is closed until the bladder is so distended, that the muscles of its upper part by their contraction overcome those at the neck of the bladder, and expel the urine.

The canals conveying the urine from the kidneys, are called ureters, and by a very simple but effectual mechanism, they convey their contents without a possibility of regurgitation, merely by passing obliquely about half an inch between the muscular and inner coats; which oblique entrance answers the purpose of a valve.

Part of the bladder is covered by the lining membrane of the abdomen; which having descended to the lower and fore part of that cavity, is reflected upwards over the top of the bladder. The neck of the bladder leads to the urethra or canal, which guides the urine altogether out of the body.

In men this channel is long and curved, because its direction is moulded to the arch of the pubis.

In females it is much shorter, and more direct.

The kidneys and bladder are the seats of a most distressing disease, when calculi or stones are deposited from the urine, either by a constitutional tendency, or from the presence of a nucleus, on which the matter is incrusted. Any part of the urinary system may contain them; more commonly they are found in the bladder than elsewhere. When their presence is ascertained they may be removed by an operation, the most formidable, and the most painful one in surgery. It consists in making an artificial opening near to the neck of the bladder, and extracting the cause of irritation.

Happily, much talent and much skill have combined to render it one of the most successful and beneficial operations practised by the surgeon.

For many obvious reasons the propriety of detailing the anatomy and the physiology of the generative organs will be doubted: and the defect is of less importance, as descriptions may be found in every anatomical publication.

While, however, the compiler of the present publication disclaims with energy all idea of wishing to gratify the prurient curiosity of a polluted imagination, and is firmly persuaded that nothing will be found in it that will be in the least offensive to the delicacy of a chastened and correct mind, he is desirous of giving such a view of his subject as will best inform the reader, and illustrate the beautiful mechanism of the human frame.

Without some explanation of the means made use of by nature for the reproduction of the species, his object would be very imperfectly obtained: and he does conceive himself entitled to a candid construction upon what he is about to communicate on that subject.

GENERAL DESCRIPTION OF THE UTERUS AND ITS APPENDAGES.

THE uterus is an organ not unlike in form and bulk a middle-sized pear. The broader part is called its fundus, the narrower extremity is its neck; this is its lower part, and it is closed by a chink which leads to the vagina, or canal communicating with the outside of the body.

The uterus is placed immediately behind the bladder, and is formed of coats that are very similar to it, excepting that they are thicker; being like those partly muscular, and partly membranous.

Besides its lower orifice there are two smaller ones leading from its fundus on each side, to corresponding tubes, which are called the uterine tubes, and which terminate at a short distance in open mouths. The extremities of these tubes have several small finger-like projections, which are loose, and allow of their grasping any body to which they may become attached. These tubes are bent towards, without however being attached to, two small bodies of an egg-like form, placed on each side the uterus, and which are called ovaries. These are firm, and without any cavity, but they have several small vesicles imbedded in their substance.

The uterus, its ducts, and the ovaries, are connected together, and covered by an enveloping fold of the peritoneal membrane, which after having covered the top of the bladder, descends in order to reascend over the uterus, and to be continued over its whole surface and its appendages.

Pregnancy.

When an intercourse takes place between the sexes, the whole uterine system experiences a peculiar irritation. The fibrous extremities of the uterine tubes grasp the ovaries, and squeeze out of them one of the small bodies we have described. This is the origin of the fœtus; and it is conveyed into the uterus along the channel, probably by a muscular power. Then the female constitution experiences striking changes; the monthly indisposition is stopped. The uterus gradually enlarges to a prodigious size; a far greater quantity of blood circulates through its vessels. Its internal surface pours out lymph, which is the bond of union between it and the vesicle: for blood-vessels shoot into it from the uterus, and enlarge its dimensions; it is now called the ovum. When it is large enough to enable us to distinguish its parts, we find it consists of membranes containing a fluid, in the midst of which floats the fœtus; at first gelatinous, and shapeless. Gradually its parts are

developed, and we find that one extremity of the ovum is attached to the uterus by a thick and spongy mass. This is the placenta, the organ by which the future infant receives its nutrition in the womb. From the centre of the placenta a cord is continued to the navel of the fœtus, along which run the trunks of the vessels of which the placenta is made up.

When nine months have elapsed, the muscular fibres of the uterus contract upon their contents; then labour commences. The lower orifice of the womb, which during pregnancy was sealed up by lymph, now gradually opens. The cone-like form which the membranes of the ovum assume, acts as a wedge, when their fluid contents are pushed against the orifice, by the contraction of the uterus. While the opening dilates, the membranes burst, the fluid runs off and lubricates the passage.

The dimensions of the head are nearly proportioned to those of the outlet, and it can escape with facility only in one direction.

The structure of the head, being made up of many pieces, enables it to be moulded to the outlet; the bones overlap each other, and the size of the head is much lessened. When the head is released, the great difficulty of labour is accomplished, and the infant is quickly born. The placenta and membranes follow the child in a few

minutes. The uterus contracts, and in no long time is reduced to its former size.

On the Fœtus, and the Changes it undergoes.

The entrance of the new-born infant into the world is accompanied with great changes in its mode of existence, and with curious alterations in its internal structure to fit it for its new situation. In one word, it is now a breathing animal instead of floating in a fluid.

Part of its organization is rendered superfluous, and gradually disappears; while other parts, which in its original state, were inactive and useless, but which have been wisely prepared for the future necessities of the animal, are now called into immediate use.

The more striking changes we have hinted at, are connected with the circulation of the blood, and the state of the lungs; these it will be highly interesting to point out.

We have before spoken of the placenta, or the organ by which the fœtus receives from the maternal blood what is necessary for its growth. It is composed of blood-vessels, yet these, it is curious to remark, do not communicate directly with those of the mother; and the mode of communication is still a mystery. The cord which connects the placenta to the navel of the fœtus, is

called the umbilical cord. It has generally three blood-vessels twining around it, namely, two arteries, and one vein. If this cord is by accident torn asunder after birth, and the dividing end towards the fœtus is not bound up, the animal bleeds to death, but the mother does not lose blood, although the placenta is still attached to the uterus, and that end of the cord is untied. The vein conveys the blood from the mother to the fœtus, after it has gone through a process in the placenta, analogous to that which the lungs perform after birth: and probably it is by the same means supplied with new materials for the nutrition of the fœtus. The arteries bring the blood from the navel to the placenta, where they branch out very minutely, are exposed to the influence of the maternal blood in cells contained in the substance of the placenta, and from which the small ramifications of the umbilical vein arise.

The vein enters the fœtus at the navel, conveys its blood by a peculiar passage, termed the "venous canal," to the great vein, the vena cava, near to the heart. It enters the right auricle, and part of it passes by an oval hole into the left auricle. This hole, like the before mentioned canal, is peculiar to the fœtal state. It is intended to avoid the circuitous course through the lungs; these being now dense, compact, and, in fact, impermeable

to so much blood: they are not yet inflated by respiration. Still, however, part of the blood enters the right ventricle; too much it would seem to find a passage through the lungs; on this account there is another canal provided, termed, in contradistinction to the former, the arterial, connecting the pulmonary artery with the aorta. The consequence is, that when the right ventricle forces its blood into the pulmonary artery, which leads to the lungs, part of it gets directly into the aorta without entering these organs, while a very small portion does in fact circulate through them; probably just enough to keep the channels open without injury to their structure.

In one or other of these ways, all the blood gets to the left side of the heart, to circulate through the fœtal system. It enters the aorta, and just below the branching of that vessel in the pelvis two arteries originate, which are the umbilical, and which pass out at the navel to carry the blood to the placenta.

Now that we have traced the circuit which the blood takes, we find this peculiarity, which, indeed, the fœtus has, in common with many animals, particularly the amphibious; that it is not furnished with pure arterial blood in its arteries; for the umbilical vein mixes its pure blood with that of the vena cava before it gets to the left side of the heart, which dilutes it with venous blood.

On the other hand it is partly arterial blood which is conveyed by the umbilical arteries to the placenta, for it has not all circulated through the system, and thus rendered venous. This state of the blood always exists in frogs. These animals have strictly one heart, namely, an auricle and a ventricle. An artery rises from the ventricle, and branches into two; one goes to the lungs, the other is distributed through the body of the animal. The pulmonary artery brings back its now altered blood from the lungs towards the auricle, where it is mixed with the venous blood returning from all parts of the system; so that here also, as in the human fœtus, the blood is never purely arterial, nor purely venous.

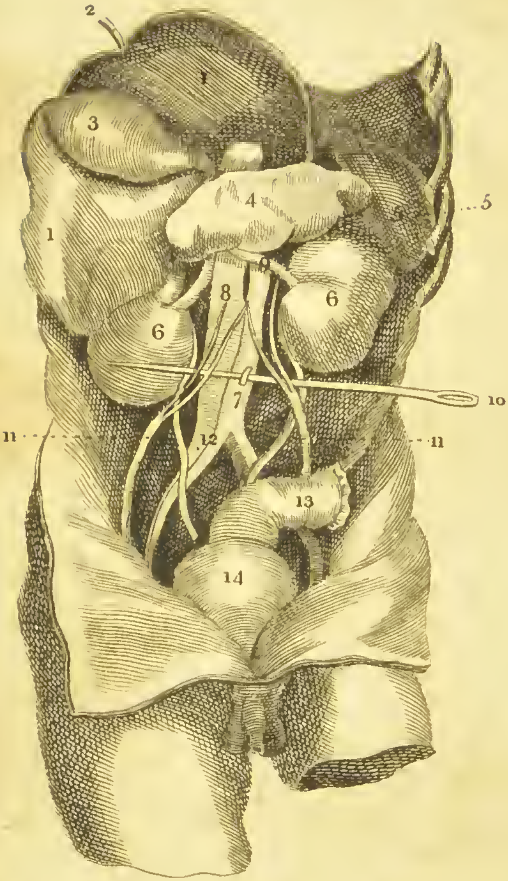
In man and quadrupeds after birth, on the contrary, the blood is carried to the lungs, altogether venous blood, and circulates through their bodies when wholly arterialised. The reason for this striking difference is not ascertained; excepting, indeed, that there seems to be a pretty uniform connection between imperfect arteriolization of the blood and languid exertion of the powers of life, as well as the converse of the proposition.

The fœtus also may be considered as having one heart, while the infant, when born, may be said to have two; one belonging to the lungs, and one to the general system. The communication by the

oval hole in the fœtus, renders the heart in effect single, its closure perfects the two circulations: and in fact the right auricle and ventricle are of no use to the fœtal system; they are provided for the future wants of the animal, and particularly for his breathing state: being wholly connected with the lungs, which we have seen to be quiescent. When the connection with the placenta is cut off, then the lungs come into play; inspiration takes place, and the blood rushes through them. The venous and arterial canals, together with the oval hole, are superseded by new channels; the latter is closed up, and the former are gradully changed to solid ligaments, instead of being hollow tubes.

New supplies of food are now requisite: a bland, nutritious, and animalized fluid, is secreted in the mother's breasts, and nature, uniformly benevolent in this part of her great work, has rendered the duties of a mother the source of exquisite gratification, and of the most endearing relations between two human beings.

Plate 5.



EXPLANATION OF PLATE V.

EXHIBITING THE DEEPER VISCERA OF THE ABDOMEN, BY THE REMOVAL OF THOSE FIRST IN VIEW.

1. The under Surface of the Liver.
2. The round Ligament by which the Liver is lifted up.
3. The Gall Bladder.
4. The Pancreas, lying upon and across the Spine.
5. The Spleen.
6. The Kidneys.
7. The Descending Aorta.
8. The Ascending Cava.
9. The Vein which returns the Blood from the Kidney
10. A Probe placed under vessels going to the Testicles.
11. The Ureters, or Vessels which carry the Urine from the Kidneys to the Bladder.
12. The Great Artery and Vein dividing into smaller vessels to go to the Lower Limbs.
13. The Lower Intestine, the Rectum, which terminates at the Anus.
14. The Bladder.

OF THE

INTEGUMENTS OF THE BODY,

WITH THEIR APPENDAGES.

THE human body is protected and ornamented by a strong, pliable, and sensible covering, which not only defends the parts underneath from external injuries, but also gives symmetry and beauty to the figure. This covering consists of several parts, each having its peculiar use and structure: we shall begin with that which lies immediately above the muscles, or flesh, and which presents itself to view on removing the skin.

Of the Cellular Membrane and Fat.

Betwixt the skin and the muscles, or flesh, and the fibres of each muscle, there is interposed a loose, oily, substance; it is continued without interruption over the whole exterior of the muscles, filling up their depressions, and affording a smooth and regular surface for the skin to lie upon. This substance is composed of a cellular texture and fat: the latter is fluid in the body, and is deposited in the cells of the former, for facilitating muscular motion; and though found in the greatest quantity in the cells of the membrane, filling up the space between the most external muscles and the skin,

yet it may be met with in several other parts of the body.

The cellular membrane, which contains this fat, is not confined to any particular part, but is to be found at every point of the body: its use and importance is very great. It serves as a bond of union, by tying and fastening all the parts together, yet in such a manner as not to prevent or obstruct their necessary motions: to contain fat, as under the skin and other places, or marrow, or serum, or a thin vapour, to render parts smooth, and moist, and flexible; and to hinder them from growing together. It yields a commodious way, or road, for vessels and nerves to glide along. It furnishes a considerable part of the linings of the great cavities of the body, and immediately covers and envelops each particular viscus of the body; insomuch that Haller supposes the greater part of the animal body to be composed of cellular substance.

Fat is deposited very unequally throughout the body. Among the viscera it is sometimes in great abundance, particularly where a constant and equable motion is required; hence the heart is imbedded in a cushion of fat, and well defended from agitation or interruption. The intestines slide over one another with great facility, owing to the masses of this substance which are interspersed

among them. On the outward surface of the body, between the flesh and the skin, it is more uniformly diffused; although even here it is in some parts more abundant than in others; as on the soles of our feet, where it serves as a cushion on which the frame rests. It fills up the chinks and crevices of the mucles, and it gives that gently undulating outline to our bodies, on which the beauty of the human form depends; while it constitutes the chief difficulty of the artist to trace its flowing curves even when we are at rest, and still more to seize its evanescent forms in the rapid succession of our motions, or in the greatest efforts of the muscular power. The fat undoubtedly answers other purposes; it defends the parts of more delicate organization from external impressions, that would injure or destroy them. It protects them from heat and from cold.

In health, and middle age, it is accumulated, perhaps, in store for the supply of the system, when other sources fail. Hence it is absorbed in disease, and taken into the circulation. In old age too its quantity lessens, when the appetite and the other functions give way.

Of the Skin.

The skin covering the human body is found to consist of three separate parts or layers, but which lie in close contact with each other, and adhere by means of numerous small vessels, and fibres which pass from one to the other.

The first layer is called the cutis, or true-skin, to distinguish it from the scarf-skin which is external to it: the cutis is spread immediately upon the adipose membrane which we have described, and is always white in people, of whatever complexion they be. This skin is exceedingly vascular, and is endowed with exquisite sensibility, being supplied with numerous nerves, whose papillæ stand out, and are the seat of feeling, as we had occasion to observe when speaking of that sense. It is extremely elastic, stretching, as in dropsy, many feet, and after tapping, returning nearly to its natural dimensions. It is thickest in those parts intended by nature to bear weight or pressure, and is therefore found to be so on the back, the soles of the feet, and the palms of the hands. It is thinner on the fore part of the body, on the inside of the arms and legs, and where its surfaces touch opposite surfaces. On the lips it is extremely thin, so as to allow the colour of the blood to shine through them. Under the inferior surface of

this skin, there are situated numerous small glands; they secrete an oily fluid, which they pour out upon the external surface of the skin, by means of excretory tubes, to keep it soft and flexible.

It is this skin in animals, which being prepared by tanning, constitutes what is called leather.

Immediately on the surface of the true skin, between it and the scarf skin, is interposed a mucous substance, on which, as we before observed, depends the colour of the body. It is black in the Negroe, of a copper-colour in the Mulatto, brown in the Egyptian, white in the Albino, and in the inhabitants of cold climates. With us it becomes brown in those exposed to the beams of the sun, and particularly so when reflected from the surface of the water, as in a sea voyage, or from the white sands, as in Africa. The colour of this mucus is transmitted from parents to their children, but is capable of great modifications: the offspring of a black man by repeated intermarriages with white women, will in the fourth generation become perfectly white, and the converse of this is equally true.

Externally to this mucous membrane lies the cuticle or scarf-skin. It is a fine, transparent, but insensible membrane, every where investing the body, and is the part of the skin which is raised in the form of bladders, by the operation of a blister.

The use of this last covering of the body is to protect the delicate nervous fibres, which stand out from the true skin, from the external air; and also to modify their too great sensibility, by interposing itself between them and the body in contact. The cuticle is perforated by innumerable pores for the passage of the perspirable matter, as will be shewn in the next article.

Of Perspiration.

An important office of the skin, and on the due accomplishment of which health very much depends, is to exhale from the body a part of the watery fluid it contains, and for this purpose it has innumerable excretory vessels opening upon its surface.

That this exhalation, though frequently insensible, is perpetually going on, appears evident from a variety of phenomena. Hold a polished, dry, clean, rubbed, piece of metal, close (without touching) to any bare part of the body, in warm weather, and it will be quickly sullied. Wipe it clean and dry, and hold it again to the part, and the same effect will be constantly renewed. And if you put your naked arm into a wide mouthed chemical glass vessel, very dry, you will soon see the internal surface of the glass dimmed with the exhalation from the limb: and if it be kept

long enough within the glass, there will be seen streaks of moisture trickling down its sides.

From this experiment it is evident that the matter of perspiration has water for its basis, and that this water is constantly flying off in subtle vapour; or when the action of the perspirable vessels becomes encreased either by exercise or heat, in this case the perspiration becomes more sensible, and is seen to exude from the skin in large quantities.

The uses of perspiration are to free the blood from its redundant water; to expel from the body those particles, which, by repeated circulation, have become acrimonious; and to cool, and regulate the heat of the system, by keeping up a constant evaporation.

Besides these exhaling vessels, the skin, as we before observed when speaking of the absorbents, is full of the mouths of lymphatic vessels: they inhale their vapours from the surrounding air either perpetually, or at least when it is not very cold; but more especially when the air is damp, the body unexercised, and the mind oppressed with grief. This absorption of the skin is proved by the operation of medicine pervading the air, or applied to the skin; such as the vapours of mercury, turpentine, &c. by the fatal effects of contagious or other poisons entering through the

skin. And it is also proved by some diseases where a much greater quantity of fluid has been discharged by the kidneys than that drank: and by animals that live in hot, moist, climates, without drink, and yet discharge a considerable quantity of fluids, both by the skin and kidneys.

The quantity of this inhaled matter in animals is difficult to be ascertained, because it is not known how far the lungs are concerned in this process of inhalation and exhalation. Indeed some philosophers have denied the inhaling powers of the skin.

It is a matter of greater certainty that the skin acts upon the air, as the lungs do in depriving it of its oxygen, and in loading it with fixed air; so that it would seem to co-operate with them in changing venous into arterial blood.

Of the Nails.

The nails are of a compact texture, hard, and transparent like horn. Their origin is a subject of dispute; yet they seem to possess many properties in common with the scarf-skin; like it they are neither vascular nor sensible, and when the scarf-skin is separated from the true skin by maceration or other means, the nails come away with it. They appear to be composed of different layers, of unequal size, applied one over the other.

Each layer seems to be composed of longitudinal fibres.

In each nail we distinguish three parts, viz. the root, the body or middle, and the extremity. The root is a soft, thin, and white substance, terminating in the form of a crescent; the scarf-skin adheres very strongly to this part; the body of the nail is broader, redder, and thicker, and the extremity is of still greater firmness. The nails increase from their roots, and not from their upper extremity. Their principal use is to cover and defend the ends of the fingers and toes from external injury; they also strengthen those parts, and prevent their bending backwards when applied with force against any hard resisting body.

Of the Hair.

It arises from distinct capsules or bulbs, which are seated in the cellular membrane under the skin. Some of these bulbs inclose several hairs, but more generally each hair has its particular bulb. The hairs, like the nails, grow only from below by a regular propulsion from the root, where they receive their nourishment. Their bulbs, when viewed with a microscope, are found to be of various shapes. In the head they are roundish, and in the eye-brows oval. Each bulb seems to consist of two membranes, between which there is

a certain quantity of moisture. Within the bulb the hair separates into three or four fibrillæ; the bodies of the hairs, which are the parts without the skin, vary in softness and colour according to the difference of climate, age, or temperament of body. They afford a light and ornamental covering to the head; serve as a defence to the delicate organs of vision, as in the case of the eye-lids and brows: and they also greatly adorn the figure by the richness of their colour, and the beautiful tresses which they form.

THE END.

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